SCIENTIFIC AMERICAN SUPPLEMENT No. 527

Scientific American Supplement, Vol. XXI., No. 527.
Scientific American, established 1846.

NEW YORK, FEBRUARY 6, 1886.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

SIR WILLIAM THOMSON'S MARINERS' COMPASS.

THE new large passenger steamships of the South-Eastern Railway Company, now plying regularly between Folkestone and Boulogne, are each furnished with one of Sir William Thomson's mariners' compasses, of which the chief features are the lightness of the needles, the keeping of the center of gravity well below the center of suspension, and various appliances for correcting sources of error. We are indebted to the *Engineer* for the following particulars and illustrations. A perspective view of the compass is given in Fig. 1; sometimes it is furnished with a rectangular box support, and sometimes it rests upon a box of another form, as represented in the cut. Various bar magnets for the permanent adjustment of the compass lie in horizontal holes bored for their reception in the sides of the box. In this compass the quadrantal error is corrected by means of a pair of solid or hollow unmagnetic iron globes, fixed on each side of the binnacle. The semicircular error is corrected by means of bar magnets placed symmetrically within the binnacle as already stated, and by a Flinder's bar outside the binnacle on the fore or aft side. The heeling error is corrected by three, two, or one bar magnets in a brass can hung by a chain, by which it can be secured at any level and in any position, in a quill tube fixed in the center of the binnacle, under the compass bowl.

Sir William Thomson states that the objects of his invention are: (1) By means of smaller needles than in compasses hitherto in practical use, to obtain as long a period of free oscillation as is suitable for working well at sea. (2) Smallness of frictional error. (3) Improved gimbals for supporting the compass bowl, to give sufficient steadiness, and to leave it greater freedom to take up as nearly as possible the true level. (4) Practical methods for applying correctors for the quadrantal semicircular and heeling errors. (5) An improved appliance to the compass for taking magnetic azimuths of sun or stars, or terrestrial objects, without being impeded by the quadrantal correctors. (6) Improvements in the method of correcting the compass by observation of the sun, moon, or stars on a detached azimuth circle.

Fig. 2 is a cross section of the rectangular box form of the compass stand, of which A B is the door, covering two rows of magnets fore and aft, represented by the unshaded lengths near C D and E F. One row of thwartship magnets is placed in the woodwork, G H. In the center, K, the can previously mentioned slides within a quill tube, and can hold three magnets if required. M N is a strip of brass covering the ends of the thwartship magnets, and by means of which they can be locked in.

The accompanying diagram, Fig. 3, will serve to show how the combination of needles is supported, so as to obtain large dimensions combined with light weight. In this cut, A B is the pivot of the compass card; A C and A F are light silk threads, connecting the compass card, F G H and C D E, with the sapphire cap, A. The silk threads, E K and L H, suspend the gridiron of magnetic needles, K L. The central sapphire cap has a light aluminum boss; the rim is of aluminum, and 4 in. to 9 in. in diameter, according to the size of the compass. In some of the compasses the dimensions of the needles composing four pairs of bars of the gridiron are 2·05 in., 2·9 in., 3·15 in., and 3·3 in.; they are all 0·042 in. in diameter. The vertical magnets are 9 in. by ⅞ in. in diameter; one, two, or three such magnets may be used according to the correction required to be made. Fig. 4 shows how the needles and the compass card are suspended.

The complete arrangement of the compass card and its surroundings is represented in horizontal section by Fig. 5, which explains itself. The compass card is partly supported by the silk threads, and partly by the aluminum rim to which these threads are attached.

In the construction of the compass it is a matter of some nicety to give equal tension to each of the threads between the boss and the rim. Sir William Thomson thus describes his method in his patent: "Each of the sixteen threads is passed through a hole in the circumference of the boss, and stretched thence into two light notches in the top of the rim, then down and through two contiguous holes on the middle of the rim; one end of the thread is then knotted, and a weight attached to the other end. The rim is placed on a suitable circular stand, and the boss is worked about until the rim is made truly circular, and the sapphire cap is truly in the center. The ends of the threads with the weights attached are then cemented to the aluminum rim, the weights are cut off, and the ends are firmly secured by means of other holes in the aluminum rim. I thus obtain a compass which, while being extremely light, and yet having a large radius of gyration, has very small frictional error with small enough magnetic moment to give a very long period of free vibration. For example, one of my compasses

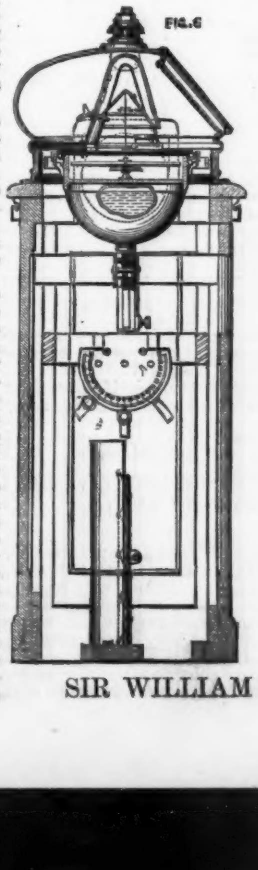
SIR W. THOMSON'S COMPASS.

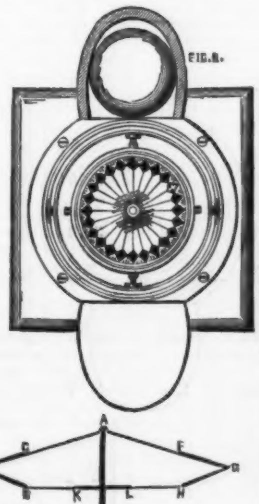
of 9 in. over all diameter, having two needles, each 2⅛ in. long, weighs in all 104 grains, and at Glasgow has a period of free vibration 62 secs., and extreme static frictional error on either side of the true position only about one-quarter degree."

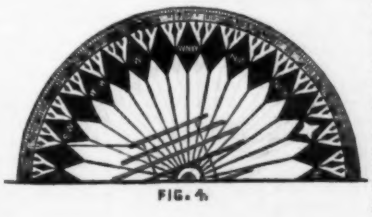
Another improvement made by the inventor is to swing the gimbals on knife-edges, instead of upon cylindrical journals, and to calm the vibration by the use of a pendant in a bowl of oil or liquid, or by means of a very viscous liquid without pendant, to give greater freedom to the compass to assume a horizontal position. A small spirit level in the glazed case in which the compass is supported indicates whether the case and bowl are properly balanced. By the use of knife-edges he loses the energy-destroying power of the rubbing surfaces, so he uses instead a large bowl attached to the bottom of the glazed case; the bottom of the case forms the roof of the bowl, and the bowl is nearly filled with liquid. Thus, when there is any motion, energy is consumed by the viscous action of the fluid. The correctors for the quadrantal and semicircular errors are founded on the principles first given by Sir G. Airy, the late Astronomer Royal, and are described in detail in the patent. The inventor further places a convex half lens over the graduated circumference of the compass card, and the lens has a plane mirror attached for observing the image of an object whose azimuth is required, and by the means provided the bearing of the object is readily seen. Another improvement consists of appliances for finding the true north by means of direct observation of the sun, moon, or any other bright star or planet; allowance has to be made for errors due to refraction.

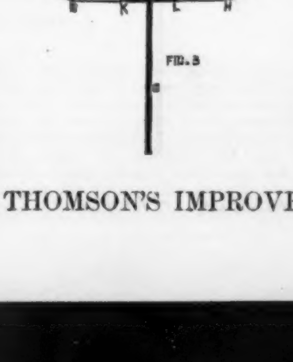
Fig. 6 is a sectional elevation of the whole instrument. Professor Thomson says that one of his compasses, of 10 in. over all diameter, having eight needles from 3 in. to 1¾ in. long, weighs in all 178 grains, and at Glasgow has a frictional error on either side of the true position of less than one-quarter of a degree. He holds that the steadiness of compasses at sea is not to be obtained by heaviness of the needles, which produces extra friction upon and dulls the bearing point, and renders the compass less steady and decided, but that the means herein stated are theoretically and practically necessary to increase the vibrational period.

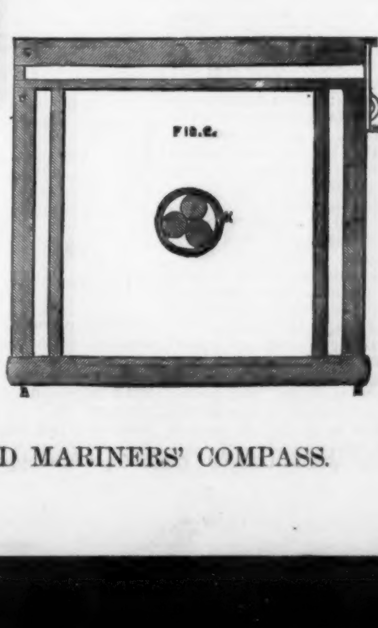
In the course of an address delivered by Sir William Thomson to the Liverpool Mercantile Marine Association, he said: "The period of the new 10 in. compass is in this part of the world about 40 seconds, which is more than double the period of the A card of the Admiralty standard compass, and is considerably longer than that of the ordinary 10 in. compass so much in use in merchant steamers. The new compass ought, therefore, according to theory, to be considerably steadier in a heavy sea than either the Admiralty compass or the ordinary 10 in. compass, and actual experience at sea has thoroughly fulfilled this promise. It has also proved very satisfactory in respect to frictional error; so much so that variations of a steamer's course of half a degree are shown instantly and surely, even if the engine be stopped, and the water perfectly smooth."











SIR WILLIAM THOMSON'S IMPROVED MARINERS' COMPASS.

NATURAL GAS FUEL, AND ITS APPLICATION TO MANUFACTURING PURPOSES.

MR. ALEX. BOWIE, of Topeka, Kansas, calls our attention to some errors occurring in an article under the above heading, which appeared in our issue of Dec. 19, 1885. In one of the calculations it was assumed that one pound of gas occupies 2·35 cubic feet. This is manifestly wrong, as an after statement places the volume at 26·31 cubic feet. The error, however, was one occurring in our copy. In another place the statement is made that if 3,761 cubic feet of this gas contains 789,694 heat units, 1,000 cubic feet will contain 210,069,604 heat units. The comma should have been a decimal point; 3·761 cubic feet would make the proportion more nearly correct. Again, however, the copy was somewhat at fault, since the number of heat units in 1,000 cubic feet would, according to this proportion, be 209,969,157·13. Some confusion has also been caused by the system of heat units employed. When the article states that 38 pounds of Pittsburg coal contains 146,903,820 heat units, it is evident that by heat unit the author means the amount of heat required to raise one *gramme* of water one degree *Centigrade*. Translated into our own system of units, the amount of heat required to raise one *pound* of water one degree *Fahrenheit*, it will be found that the heating value of the coal has been correctly stated.

LACQUER WORK OF THE BURMANS.

THE Burmese lacquer work is not unlike that of China and Japan, but is made exclusively of small bamboo strips. These latter are woven into circular boxes of all sizes, from betel-pouches to house-trunks. The first step in the lacquering is to smear the box with a mud containing (or not, according to quality) a proportion of the black varnish called *thitsee*, obtained from *Melanorrhœa usitatissima*. Next follow sun-drying and polishing in a lathe with soft sandstone and water. A coat of the varnish, mixed with bone-ash, is then applied, and rubbed down; another coat, containing less bone-ash, and another rubbing down

succeed; then a final coat of varnish is polished, giving the box a smooth, brilliant, black surface. The pattern is put on in black and red. First, black lines are run round the box by a kind of style or point, fixed in a bit of wood or bamboo, so as to leave a slight projection, the point being charged with black varnish; on rotating the box in the lathe in contact with this style, the necessary black lines are produced in relief. These being completed, the box is entirely covered with a coating of a red paint made from vermilion ground up in a vegetable oil (*shantsee*), so thick as to conceal all the black lines. This dry, a rubbing down with rice-husks and water in the lathe removes the red color from the prominent black lines. Any additional colors are successively applied, and the pattern developed by a steel style, pointed at one end and flattened at the other. The market value of the finished box depends on its elasticity and the fineness of the pattern. The best will suffer bending double, without injury to the lacquer; a 3-inch betel-box of this quality may fetch as much as a couple of guineas.

[Continued from Supplement, No. 526, page 8398.]

THE MANUFACTURE OF TOILET SOAPS.

By C. R. Alder Wright, D.Sc., F.R.S., F.C.S.

Lecture III.

GENERAL CHARACTER OF TOILET SOAPS AS SOLD IN ENGLAND.

The number of soaps sold in this country that can be classified in the first rank, in accord with foregoing system of requirements, is very small as compared with those that fall into the second and third classes, so far as a somewhat wide analytical experience of them enables me to judge; thus the tables herewith contain the results of the analyses of a few specimens of British manufacture, selected from a much larger number as typical examples; for obvious reasons, the trade marks and makers' names are not stated. A certain number of soaps of Continental origin are also included in the tables. The figures representing the "retail price per pound of actual soap" are instructive; they are arrived at in the following way: The average weight of tablets, as sold to purchasers, being determined, the retail price being known, and the percentage of actual soap present (apart from water, saline matters, etc., also contained) being known by analysis, the price is calculated by the formula:

$$x = \frac{16}{w} \cdot \frac{100}{s} d = 1{,}600 \frac{d}{ws}$$

where x = "retail price per pound of actual soap," in pence.
w = average weight, in ounces, of tablet as sold.
s = percentage of actual soap.
d = retail price per tablet, as sold, in pence.

Thus, suppose the soap to be sold in eighteen-penny boxes of three tablets, *i. e.*, let $d = 6$; let each tablet weigh on an average 3·2 ounces (or five tablets to the pound); and let the soap contain 75 per cent. of actual soap; then:

$$x = 1{,}600 \frac{6}{75 \times 3{\cdot}2} = 40$$

so that the retail price per pound of actual soap is 40 pence, or 3s. 4d.

The amounts of "free alkali" stated in these tables are uniformly reckoned per 100 parts of alkali actually combined as soap, so that according as these amounts fall below 2·5, between 2·5 and 7·5, or above 7·5, the soap would be classed as of the first, second, or third grade respectively, if judged solely by the criterion of free alkalinity. The "classification" given in the tables, however, is not based solely on this criterion, but on this conjointly with the character of the soap as a whole, and its freedom or otherwise from adulterants, "filling," and water and "closing up" agents, and from poisonous coloring matters; and also with the nature and quality of the fatty matters used as basis, their freedom from rancidity either before making into soap or subsequently, and so on.

No great stress is laid on the delicacy or character of the perfume, nor on the perfection of finish of the tablets, in classifying the soaps, because, although these points affect the price to some extent through entailing a greater amount of labor or a greater cost for perfume, they have no real connection with the intrinsic qualities of the soap as such.

Taking into consideration not merely these, but also all the other numerous analyses made, I have arrived at the following conclusions, as regards the general nature of the various toilet soaps sold in this country:

1. *As regards Opaque Soaps.*—A limited proportion of excellent soaps are to be had, containing not more free alkali than corresponds to one-fortieth part of the combined alkali, and made from good, sound materials in the way of fatty matters, etc., serving as basis. In these soaps the percentage of actual soap present ordinarily varies from 70 to 90, according to the mode of manufacture and to the amount of other non-saponaceous matter added for special reasons (*e. g.*, glycerin), the percentage of water usually ranging from 6 or 7 to 20, and sometimes slightly exceeding the latter amount. The retail price of these soaps, reckoned per pound of actual soap, varies from two shillings and nine pence to eight or ten shillings; these figures correspond with from four-penny tablets of about six to the pound, containing 70 to 75 per cent. of actual soap (or six-penny tablets of four to the pound, containing about the same percentage) to eighteen-penny or two-shilling tablets, of about 3 or 3½ ounces in weight, and containing 85 to 90 per cent. of actual soap.

By far the majority, however, fail to attain such excellence as to entitle them to be placed in the first class, excessive alkalinity being the most conspicuous fault. A considerable number of soaps sold at sixpence and upward per tablet are excluded from the first class, and some even ranked only as third class soaps, solely from this cause. Similarly, numerous soaps, the retail prices of which lie between two and three shillings per pound (tablets sold retail at threepence and fourpence) have to be placed in the third instead of in the second class, solely for this cause. A few cheap soaps (two-penny tablets) are sufficiently good to be ranked in the second class, or very close to it; but the majority of tablets retailed at prices representing tenpence to eighteen-pence a pound (penny and two-penny tablets) are utterly unworthy to be termed toilet soaps at all, being usually made from more or less coarse or rank materials, often with a large excess of alkali, and generally containing considerably upward of 25 per cent. of water, with large amounts of sulphate of soda or other saline matters to "close up" and harden the mass. Such tablets, when kept for some time in a dry place, usually become more or less incrusted with saline efflorescence, losing their shape as they dry.

OPAQUE TOILET SOAPS.—UNTINTED.

British.

Free alkali.	Percentage of actual soap.	Retail price of actual soap per lb.	Remarks.	Classification based on general characters, amount of free alkali, and nature of fatty acids.
		s. d.		
6·6	73	0 11	Tallow curd with a little cocoanut oil. Turned brownish on keeping a few weeks. Odor not very rank, but distinctly tallowy.	III.
2·3	79	1 0	Much the same general characters as the preceding, but more marked tallowy odor.	III.
6·0	84	2 2	Faintly perfumed; contained some cocoanut oil, but without objectionable odor in use.	II.
10·5	71	3 4	Contained several per cents. of oatmeal; nicely scented, but objectionably alkaline. A perfumers' soap of fairly typical quality.	III.
20·8	70	3 4	Contained 8 per cent. of French chalk. Most objectionably alkaline, yet advertised as a specially pure skin soap.	III.
13·0	70	3 5	A British perfumers' soap, delicately scented, but turning brownish on keeping. Objectionable excess of alkali.	III.

CHEAPER CLASS OF OPAQUE TOILET SOAPS.—TINTED.

British.

Free alkali.	Percentage of actual soap.	Retail price of actual soap per lb.	Remarks.	Classification.
		s. d.		
7·0	76	1 3	Tinted yellow with soluble organic coloring matter; largely made of cocoanut oil, but possessing no marked rank odor. Somewhat alkaline.	II.
5·9	81	1 6	Sold as "Glycerin" soap, but absolutely devoid of glycerin. Resinous odor. Tinted yellow with organic coloring matter. An inferior kind of resin soap.	II.
8·5	78	1 7	Moderately good curd soap, but too alkaline. Chiefly tallow with a little cocoanut oil. Tinted red with mercurial sulphide.	III.
13·5	73	2 2	So-called "Brown Windsor" tinted with burnt umber. Highly alkaline.	III.
6·0	64	2 5	So-called "Glycerin," but only containing 0·4 per cent. of glycerin. Tinted dull orange, with organic color. Agreeably scented.	II.

SUPERIOR CLASS OF OPAQUE TOILET SOAPS.—TINTED.

Free alkali.	Percentage of actual soap.	Retail price of actual soap per lb.	Remarks.	Classification.
		s. d.		
			British.	
Nil.	83	2 9	Tinted orange with soluble organic coloring matter; pleasantly scented. The cheapest of all the soaps examined that could fairly be called first-class.	I.
6·5	78	2 11	Tinted green with a mixture of ultramarine and yellow soluble coloring matter; agreeably scented. Became very dingy colored on keeping.	II.
7·6	67	3 3	Tinted with chlorophyl, the color fading speedily on keeping. Pleasantly scented, but notably alkaline.	III.
1·0	86	4 3	Tinted pink with mercurial sulphide. Delicately scented rose.	II. Almost I.
			Continental.	
Nil.	84	3 0	Tinted pink with organic coloring matter. Pleasantly scented rose.	I.
1·5	92	4 10	Tinted dull pink with mercurial sulphide. Deliciously scented.	II. Almost I.

TRUE GLYCERIN SOAPS NOT ADULTERATED WITH SUGAR.

	Free alkali.	Percentage of actual soap.	Percentage of glycerin.	Retail price of actual soap per lb.	Remarks.	Classification.
				s. d.		
OPAQUE.					*British.*	
	9·0	74	6·0	1 3	Nearly white, slightly rank odor, unscented; largely made from cocoanut oil. Objectionably alkaline.	III.
					Continental.	
	1·3	55	4·9	3 10	White: contained 16·5 per cent. of unsaponified fat. Mostly cocoanut oil, but no marked rank odor. Wastes rapidly in hot water.	II.
	Nil.	74	7·9	5 3	Tinted mauve with organic coloring matter. Delicately scented.	I.
TRANSPARENT.					*British.*	
	1·5	60	14·3	6 5	Made with pure alcohol (not methylated spirit). Slightly scented. Wastes rather rapidly in hot water.	I.
	7·0	26	17·6	9 7	Supposed to contain half its weight of glycerin. Very wasteful in use, melting completely in hot water.	II.
					Continental.	
	1·6	33	35·0	7 6	Pleasantly scented, but very wasteful in use. Melts completely in hot water.	I.

Tinted soaps, whether of high or low price, are very frequently colored with pigments containing poisonous metals, mercury (as vermilion) and lead (as red lead) being not unfrequently to be found therein, and sometimes arsenic and copper.

A very considerable fraction of the cheaper soaps sold as "Brown Windsor" owe at least a portion of their color to alteration and oxidation of the soap, either during manufacture or subsequently, inasmuch as there is

TRANSPARENT SOAPS CONTAINING SUGAR.

Free alkali.	Percentage of actual soap.	Percentage of sugar.	Retail price of actual soap per lb.	Remarks.	Classification.
			s. d.	*Made with Spirit.*	
Nil.	70	10	4 8	Made with methylated spirit, and possessing in consequence an unpleasant odor only imperfectly disguised by perfume. The cheaper soap sold as containing 30 per cent. of glycerin, but actually containing none at all.	II.
Nil.	68	10	18 0		
8·5	52	26	2 2	Made with methylated spirit; objectionably alkaline.	III.
				Made without Spirit.	
20·8	52	18	2 6	Fairly representative specimens of different kinds of transparent soaps not made by solution in spirit. Largely prepared with cocoanut oil, and generally strongly scented to disguise rank odor. Largely mixed with sugar, and in consequence very wasteful in use, rapidly dissolving in hot water. Always most objectionably alkaline.	Low down in Class III.
19·0	48	28	5 10		
25·8	45	22	2 6		

reason to believe that this change is occasionally accompanied by the development of a tendency to irritate sensitive skins; such soaps, as also those tinted originally with pretty colors that have become dull and dingy on keeping, should be avoided.

2. *As Regards Transparent Soaps.*—Almost all the transparent soaps made by cold processes (often sold as "glycerin soap") that I have met with contain large amounts of free alkali, exceeding 10, and sometimes exceeding 25 per cent. of the alkali present combined as soap; they rarely contain more than half their weight of actual soap, the remainder being chiefly water, sugar, and salts added to "close up" and harden the mass (carbonate of soda thus added being a source of much of the excessive alkalinity). The low percentage of actual soap and the high percentage of sugar (often 20 to 25 per cent., and even more) render this class of soap not only very wasteful in use, from the easy solubility (some kinds actually *melting* in hot water), but also much more deleterious to tender skins than soaps not containing sugar and of high percentage in actual soap, because much more alkali is brought into contact with the skin in use, owing to the more rapid solution; apart from the larger amount of free alkali present, and also from the fact that these soaps consist largely of cocoanut oil soap, which hydrolyzes more rapidly in contact with water than most other kinds.

Notwithstanding their defects from a chemical point of view, these soaps have of late years come largely in demand, mainly on account of their attractive appearance; they cannot, however, be termed economical, as the price, when reckoned per pound of *actual soap*, is somewhat high with the better kinds, owing to the low percentage of soap present (four-penny tablets of five to the pound, and containing 45 per cent. of actual soap, represent three shillings and eightpence *per pound of actual soap*), while lower-priced kinds, costing two shillings to two shillings and sixpence per pound of actual soap (two-penny and three-penny tablets), are often made from materials so coarse and rank as to leave a most disagreeable odor on the skin after use, not at all perfectly disguised even by the addition of strongly scented essential oils, etc., in large quantity. In fact, the cheaper classes of transparent soaps, made without spirit, are, as a rule, decidedly the worst value for the money of any in the market, being very far inferior in quality to many household soaps costing much less than half the price.*

On the other hand, transparent soaps made by dissolving stock soaps in boiling spirit are, as they are actually sold, by no means always as good as they might be, although they generally (but not invariably) have the merit of being very nearly neutral. Some few are to be bought made with pure alcohol (not methylated spirit) from stock soaps of thoroughly good quality, the transparency being aided by the addition of some ten to fifteen per cent. of glycerin, and these are of the very first rank as soaps; but far the largest proportion of this kind of soap sold consists of stock soaps (often of inferior grades) rendered transparent by means of methylated spirit, sugar being also substituted for glycerin; and the experience of several of my own friends and members of my own family in connection with this kind of make is, that the use for a short time of such a soap is liable to bring about blotching and irritation of the skin to a very marked extent. Whether this is due to rankness of the fatty matters used in making the original soap or to substances derived from the methylated spirit, it is difficult to say; but the experience of various specialists in skin diseases, as regards the effects of such soaps on persons possessing tender, sensitive skins, is, I am informed by them, in exact conformity with the experience of my own friends, as just stated.

On the whole, it appears that there is much room for improvement in the general character of the toilet soaps in the British market, where good soaps, well made from sound materials, and devoid of free alkali, are far less numerous than articles inferior in some or all of these respects. To a great extent, however, the public has only itself to blame in the matter, inasmuch as (just as in many other instances) it persists in demanding articles to be supplied at prices incompatible with high quality, while it takes no pains to protect itself against the numerous frauds, adulterations, and misrepresentations thereby rendered inevitable, many of which would be punishable were toilet soaps and articles to come into the category of "food, drink, or drugs," so that penalties would attach to the selling of goods under false names, such goods "not being of the nature and quality demanded." It is true that no particular harm is done to the purchaser of a cake of "honey"* soap, should such soap contain no honey at all, as is usually (though not invariably) the case; but if an article is advertised as superior to others, and sold at an enhanced price, on the ground of its being said to contain certain ingredients which are not present at all (as, for example, in the case of soaps guaranteed to contain a high percentage of glycerin, or advertised as specially suited for application to the skin because sulphur is an ingredient, when in point of fact no trace of glycerin or of sulphur is present), it is evident that the purchaser is just as much "damnified" as he would be were he to purchase "bosch" butter, or oleomargarine, at the price of genuine cows' butter, or were skimmed or watered milk sold to him instead of the unsophisticated article. That soap-makers do not look at the matter from this point of view, however, is evidenced by the fact that in the International Health Exhibition not one but several makers exhibited and supplied to the jury for analysis soaps stated to contain glycerin (in one case 30 per cent. being guaranteed), all of which were actually entirely devoid of that constituent, sugar being in some cases substituted for glycerin, in others not. Similarly, various other soaps were exhibited, professedly containing certain other ingredients, notably *milk*, *cream*, and *sulphur*, all of which were really conspicuous by their absence.†

During the course of these lectures I have been repeatedly asked "How is the general public to judge which soaps are really intrinsically good and safe to use even by sensitively skinned persons?" and also, "How are manufacturers to know whether their soaps are imperfect in any important respect, so as to remedy the defect?" At a time when second and third rate articles are everywhere puffed and recommended from interested motives, the existence of a large demand is by no means necessarily a criterion of excellence; on the other hand, to satisfy the requirements of the public for cheapness, manufacturers are compelled to send out a large number of articles not so good in quality as they would be were the public at large willing to pay higher prices for superior makes. Naturally, every one wishes to place his goods in the most favorable light before the public, and consequently it is not unusual in the soap trade, as in many other businesses, to obtain certificates of analysis for publication, so that the public may have some sort of guarantee of quality (apart from the maker's reputation). The fault in this system lies in the fact that an analysis of a single sample (possibly of superior quality, selected for the purpose) affords no sort of guarantee that the goods supplied in quantity to the public are of the same quality as the specimen to which the certificate applies; and this is now so well understood that an analyst's certificate has come to be looked upon rather as an ordinary trade puff than as a genuine statement of the character of the goods as sold. To make such a document of any real value to the public, it is requisite that the certificate should apply *not to a single sample sent for the purpose of obtaining a favorable report, but to the general character of the manufacture as deduced from frequent inspection and periodical examination of the materials in all stages of production.* Of course, the scientific position and general reputation of the analyst supplying the certificate require to be also taken into account in determining how far the analytical report may be trusted as applicable to the goods as actually retailed. Until such time as the sale of soap, at any rate of toilet soaps, is put under the same kind of restrictions as those whereby the sale of unwholesome or adulterated food is attempted to be repressed, so that articles calculated to do injury to the skin or improperly described can only be sold at the risk of fine or other punishment, purchasers must be content either to find out by trial which particular kinds of soap affect them unpleasantly, so as to eschew these for the future, or to purchase on the recommendation of some one competent to advise on the subject. As long, however, as copious advertising will attract numerous buyers, quite irrespective of the real nature of the goods puffed, so long will articles very far from first-rate in quality meet with a sufficiently ready sale to render their manufacture profitable, and so long, therefore, will such goods be continually pressed on the public attention. *Caveat emptor!* Let the purchaser beware!—*Journal Society of Arts.*

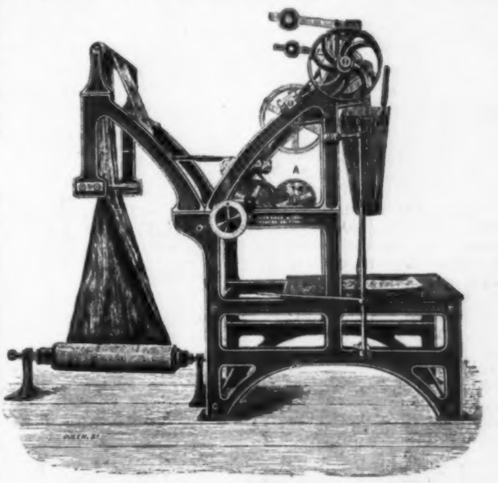
* A good grade of yellow soap retailed in bars at fourpence a pound, and containing, say, 67 per cent. of actual soap, represents sixpence per pound of actual soap; while, as regards alkalinity and quality of materials used in making this soap is generally quite as good as even the best transparent soaps made without spirit, and far better than the lower kinds of such transparent soaps.

* Many of the so-called "honey" soaps sold owe their texture to extreme pearlashing, and consequently contain considerable amounts of free alkali, even when made from materials otherwise unobjectionable.

† It is worthy of notice in this connection that as far as my own observations go, misrepresentations of this kind are far less common among Continental soap-makers; thus, I do not remember ever coming across a sample of so called "glycerin soap" of Continental manufacture that did not actually contain at least some per cents. of glycerin.

MARKING AND MEASURING MACHINE.

IN the retail drapery trade it is obvious that it would be a great convenience to the draper if the cloth which it is his business to sell by length be marked at intervals near the margin with figures indicating the number of yards still remaining of the piece after portions of it have been sold. It enables him to estimate his stock with little trouble, and to be better informed in giving orders for its replenishment. It therefore appears that within the last few years it has become a very general requirement of the trade that the pieces they order should be measured and marked at frequent intervals along one of their edges, in addition to the usual indication of their total lengths. This interval is commonly every five yards. The dealer has then only to take a roll of cloth off his shelves, and unroll for less than five yards, until the first number becomes visible, and will tell at a glance the length of cloth that remains unrolled. The enumeration goes backward as the cloth is unrolled—that is to say, as the numbers appear, each is less than the preceding one by five or otherwise. The length of the cloth is measured from the end of the piece inside the roll, the first number from the end being 5, the second 10, and so on. The ordinary mode of measuring and marking involves considerable labor and time, the plan being to draw the piece over a table about 6 yards long, one edge of which is divided in yards, and marked from one end of the table. In front of this end a girl sits, and, in commencing to measure a piece, she places its beginning at the end of the table; another girl standing at the 5 yard mark now gums on a small label with 5 upon it, after which the cloth is drawn along by the first girl until this label coincides with the end of the table, when another label with 10 upon it is gummed on opposite the 5 yard mark. This procedure is repeated with 15, 20, etc., labels until the end of the piece is reached. Suppose it is to be 77½ yards long, the last label will be 75, and then odd 2½ yards is measured by the graduations in the table, and the total length is marked on the piece. The purpose of this article is to describe an apparatus by which this measuring and marking, which as above described is a distinct and additional operation, may be automatically performed simultaneously with the operation of creasing or rigging, but may, of course, be done independently when the creasing or doubling up the length is not desired. This marking apparatus under notice is as designed and patented by Messrs. James Farmer & Sons, engineers and machinists, Adelphi Street, Salford, and as herewith illustrated is



IMPROVED MARKING AND MEASURING MACHINE.

shown applied to their construction of creasing and measuring machine. The printing and inking arrangement is shown at A. Its mechanism is very simple, and is self-contained within a disk about 12 in. diameter, which may be moved along its shaft into any position to adjust for different widths of cloth. The printing is done against the measuring roller by a set of figure types (5, 10, 15, etc.) linked together into a chain and carried by the disk, A. The action of the mechanism is such that for every 5 yards paid off by the measuring roller the chain is advanced one type, and therefore the succession of figures is duly printed on the cloth. An important point to note is that the surface speeds of the measuring roller and the marking disk are alike, and therefore the numbering is perfectly clean and sharp, the figures being comparatively small (about ⅜ in. in size). The types ink themselves automatically from an ink receptacle, also carried in the disk. This receptacle consists of a small cylinder covered with flannel, which absorbs the ink and transfers it to the type in the quantity required to give a clear impression of the figures, neither too faint or blotted with an excess. The cylinder contains a sufficient supply of ink for about one month's continuous working. It is removable, and may be substituted by another cylinder containing a different colored ink; and by having several ink cylinders the colors may be varied to suit the shade of the fabric, so that the figures may appear as distinct as possible. The lengths of pieces, of course, vary greatly, reaching up to, say, 100 yards. It is, therefore, generally sufficient for the markers to indicate on the margin every interval of 5 yards up to this length, and accordingly they are made to accomplish this result. The method of working is as follows: The end of the piece to be measured, and, if necessary, creased, is brought down until it touches the surface of the table. The marker is turned to zero, and also the finger of the dial, B, of measuring roller. The machine being started, 5, 10, 15, etc., are printed at the correct position until it becomes necessary to stop the machine to cut out the first piecing or joint in the fabric. The dial includes the total length; suppose it to be 81½ yards, then the last printed number would be 80 yards. The joint being cut away, the beginning of the next piece is brought to the table, the marker and dial finger are put at zero, and the operation is proceeded with as before. The arrangement is both simple and accurate. It may also be applied to many existing machines, and as it is designed to meet a decided want, it is well worthy of the notice of manufacturers and finishers.—*Textile Manufacturer.*

CHICAGO FOUNDATIONS.

By Harry Lawrie.

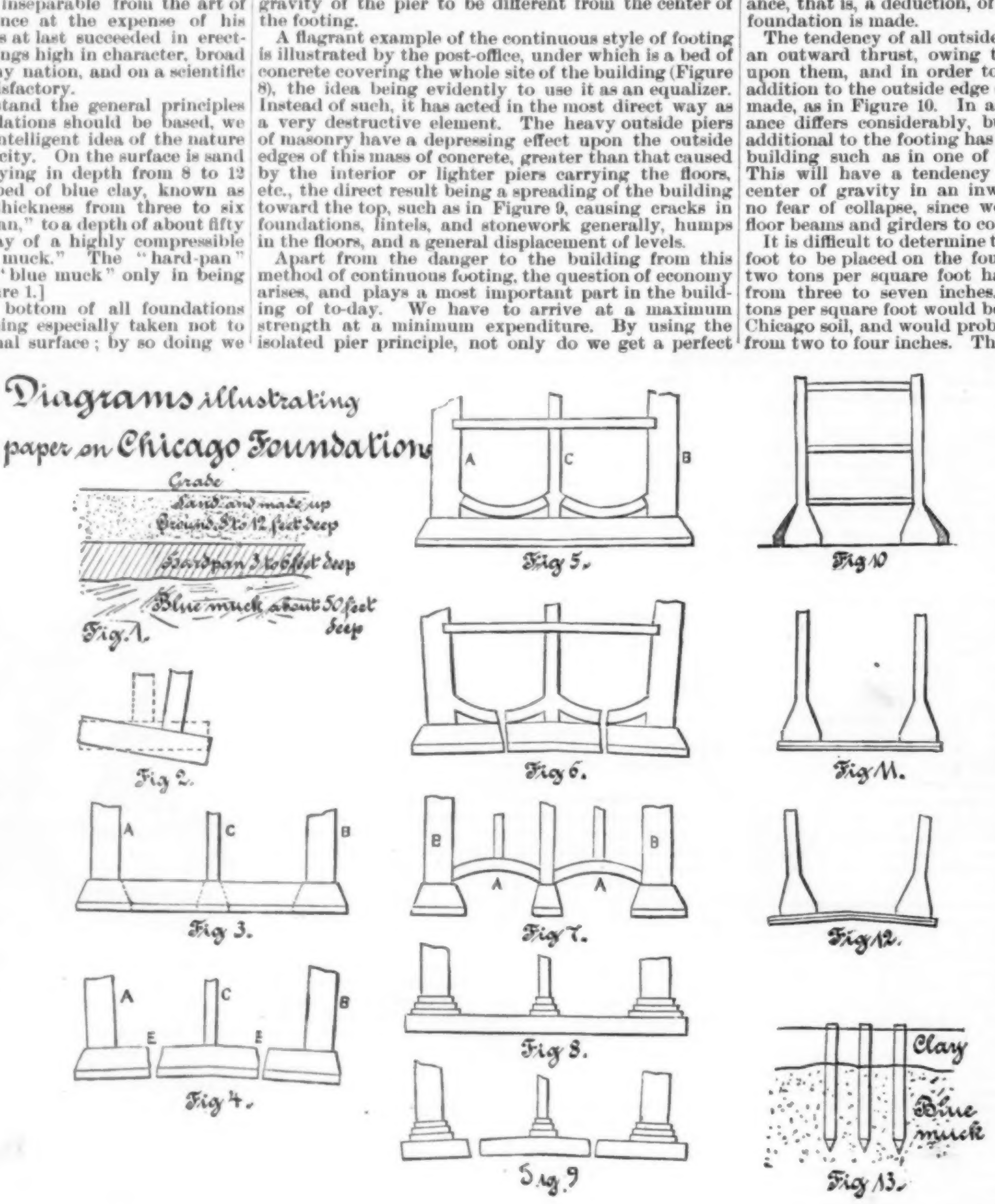
The intention of this paper is not to give an exhaustive treatise on Chicago foundations, but to bring before you the general principles upon which they ought to be based. Within the memory of the present generation, or about thirty-five years ago, it was no uncommon circumstance to see, in the vicinity of State Street, down town, a placard, placed in a slough of mud and water, with the ominous words printed thereon, "No bottom here." Such a state of things might have deterred the average mind from attempting any building operations there; but the Chicagoan, nothing daunted, erected structures on a soil as compressible in those days as a sponge, and gradually, by dint of hard labor, both mentally and physically, but amid many vicissitudes, inseparable from the art of building, gaining experience at the expense of his pocket and reputation, has at last succeeded in erecting on the same soil buildings high in character, broad in design, a credit to any nation, and on a scientific basis that is eminently satisfactory.

In order fully to understand the general principles upon which Chicago foundations should be based, we must have a distinct and intelligent idea of the nature of the soil underlying the city. On the surface is sand and made-up ground, varying in depth from 8 to 12 feet, and below this is a bed of blue clay, known as "hard-pan," varying in thickness from three to six feet. Below this "hard-pan," to a depth of about fifty feet, is a bed of wet clay of a highly compressible nature known as "blue muck." The "hard-pan" seems to differ from the "blue muck" only in being partially dried. [See Figure 1.]

On this hard-pan, the bottom of all foundations should be placed, care being especially taken not to remove or break the original surface; by so doing we at once destroy the homogeneous mass, and reduce it in thickness, hence its carrying capacity.

Before foundations are commenced, a sufficient number of borings should be taken over the entire site, to determine the average thickness of the hard-pan; and should any great inequalities exist, care should be taken to strengthen, at these weak points, the footings which come thereon.

This clay is more or less compressible, and upon all compressible ground the successful erection of any ordinarily heavy building, such as a large office building, warehouse, theater, or public building, involving considerable weight of materials, the following well-known and recognized principles should be applied: (1) Resolve the building into isolated piers on the ground or basement floor, and give to each its proper proportion of foundation, commensurate with the weight carried; that is to say, the areas of the foundations must be in exact proportion to the load carried thereon. (2) The load carried by the foundations to be placed centrally thereon, the center of gravity of the pier coinciding with the center of the foundation.



In the first principle mentioned, the subdivision into isolated piers may be somewhat difficult, more especially where piers and high walls, such as "party walls," abut, or where vaults are in close proximity to, or abutting, the main piers of the building. Such cases can only be dealt with upon the principles laid down and applied to the best of the architect's ability to deal with such points.

Having resolved our building into isolated piers, the second principle is applied. Suppose, as a *reductio ad absurdum*, that the load is not placed centrally on the foundation; the natural result would be that, owing to the compressible nature of the soil, the base would assume an inclined plane, the depression being toward the end where the load was put, and the axis thrust out of its perpendicular line, for it must retain its original angle with the base, and will assume such a position as represented by Figure 2, the dotted lines showing original position of foundation and load.

In Figure 3 we will suppose a store front with heavy piers at A and B, and a lighter intermediate pier at C, with a continuous footing under the whole, in order "to get all the strength" we can.

The inevitable result would be that the heavy piers, A and B, would so depress the compressible soil that the foundations would form a convex curve as shown by Figure 4, while the foundations would rupture at points E; the lintels and beams, if of stone, would crack; the mullion, or pier, C, might bend or be forced out of its perpendicular line and a variety of mishaps might occur, all of which would be injurious to the building. If the footings under the piers A, B, and C had been isolated, and made proportionate to the loads carried, as shown by dotted lines (Figure 3), the settlement would have been equal, and no such trouble as above stated would have occurred.

Take another example in Figure 5, with a continuous footing under the buildings and inverted arches placed between piers A and B to carry intermediate and lighter pier C, these inverted arches being ostensibly inserted for the purpose of spreading the load on the continuous footing. The results are the same as before mentioned, namely, a greater depression where the heavy piers occur than at the lighter ones, a rupture in the continuous footing, a breaking and cracking of girders and lintels, etc., as in Figure 6. But the same remedy can be applied, namely, an isolated foundation to each pier properly proportioned.

Take another example, in Figure 7, where arches are thrown from one pier to another in order to support part of the superstructure. The outward thrust of the arch, A, will have a tendency to displace the center of gravity of pier B, and destroy its verticality.

In all the above examples, the direct tendency of the continuous footing is to add something additional to one side of the foundation under the pier, and therefore violate the second principle, causing the center of gravity of the pier to be different from the center of the footing.

A flagrant example of the continuous style of footing is illustrated by the post-office, under which is a bed of concrete covering the whole site of the building (Figure 8), the idea being evidently to use it as an equalizer. Instead of such, it has acted in the most direct way as a very destructive element. The heavy outside piers of masonry have a depressing effect upon the outside edges of this mass of concrete, greater than that caused by the interior or lighter piers carrying the floors, etc., the direct result being a spreading of the building toward the top, such as in Figure 9, causing cracks in foundations, lintels, and stonework generally, humps in the floors, and a general displacement of levels.

Apart from the danger to the building from this method of continuous footing, the question of economy arises, and plays a most important part in the building of to-day. We have to arrive at a maximum strength at a minimum expenditure. By using the isolated pier principle, not only do we get a perfect foundation, or nearly so, compared with the others, but we do so at a greatly reduced cost, for we effect a saving by dispensing with all unnecessary material.

It is a simple question to determine the exact weight of solid masonry that comes on any given footing, but it is a somewhat difficult problem to lay down hard and fast figures for the weight per square foot of floorage carried by said footing.

The load of solid material is a known quantity, since we know the weights of the various materials supported by the footing; but when we begin to make our calculations for weights on floors, we at once deal to a certain extent with a theoretic load, to a certain extent be it observed, for we know the exact weight of the floor construction, but beyond that point the figures are purely theoretical.

Our floor-beams and girders are calculated to sustain say 120 to 130 pounds per square foot. If we were to allow for the whole of this weight on each floor being transmitted to the foundations, it is at once evident that our allowance would be too great, for we suppose every floor would be loaded to the full capacity, an almost impossible circumstance in any ordinary building, the result being that that pier would settle less than those on which the solid masonry came, disturbing the floor level and generally injuring the structure by unequal settlement.

As a factor of safety for floor load on foundations, an allowance of from five to eighteen pounds per square foot over and above actual weight of floor construction is commonly allowed, the exact amount so used to be determined by the architect, according to the style and use of the building.

In treating interior piers, or iron columns, in a building with heavy outside walls, another point arises, and one which has considerable play on the equal settlement of the building: The clay, which, as we have pointed out, being more or less compressible, will, by the weight of the outside wall or piers, be forced up in the interior of the building, forming a convex curve, the exact nature and extent of which can only be theorized upon, but this convexity will certainly form an element of danger to the lighter interior piers by thrusting them upward, if we may so express it. This upward tendency will therefore require to be counteracted, and that can only be accomplished by reducing the area of the footing, or, in other words, employing a larger factor for the load per square foot of foundation. This reduction varies in different parts of the city, and can only be determined by experience and experiment—experience being the better school.

Where interior piers or iron columns support floor loads and nothing else, that allowance will require to be greater, since we have seen that all the floors will, in all likelihood, never be loaded to their full capacity at one and the same time. In some cases, an allowance, that is, a deduction, of 12 per cent. on the area of foundation is made.

The tendency of all outside walls and piers is to have an outward thrust, owing to the weight of the floors upon them, and in order to counteract said thrust an addition to the outside edge of their footings should be made, as in Figure 10. In actual practice this allowance differs considerably, but as much as 10 per cent. additional to the footing has been made, say in a heavy building such as in one of eight or ten stories high. This will have a tendency to throw the pier off its center of gravity in an inward direction, but there is no fear of collapse, since we have the strength of the floor beams and girders to counteract any thrust.

It is difficult to determine the exact weight per square foot to be placed on the foundations. In some cases, two tons per square foot have shown a depression of from three to seven inches. One and three-fourths tons per square foot would be a safe load on ordinary Chicago soil, and would probably give a depression of from two to four inches. The exact factor to be used should be determined, if possible, by the results of the borings through the clay, and if this result cannot be obtained before the building is ready for erection, a safe factor, say 1·60 or 1·75, should be employed.

The materials used in foundations are various. Brickwork ought to be used in foundation piers with great care, selecting the best hard-burnt and well-shaped bricks, building them in cement. Such brickwork will bear from six to eight tons per square foot with safety, and in some cases as high as ten tons per square foot. The great trouble with brick footings is their liability to crush under a great load, and, unless the footings are so proportioned as to receive a load of say six to eight tons per square foot, another and stronger material had better be employed. Brick in cement will crush at from 450 pounds to 1,000 pounds per square inch, and, allowing a factor of safety of six, which is low, would give in tons five to twelve.

Rubblework well-built and squared at the points, in large stones, forms an excellent footing built in cement; such mason work will safely sustain a load of from twelve to fifteen tons per square foot. Dimension stone is an expensive item, and, except under exceptional circumstances, should only be used in bond courses. The offsets on these foundations should be carefully studded. Those in brickwork should be about three-fourths to one inch per brick for heavy footings. In rubblework, with courses of about fourteen to eighteen inches high, offsets of from six to ten inches are sufficient, and in dimension stone, say one foot and two inches high, the offset can be twelve inches.

Concrete should only be used as an equalizer, and placed at the bottom of foundations. The load which can safely be put upon it is about four to six tons per square foot.

In building footings, they are sometimes constructed with a hollow space to allow the masonry to dry out, and to prevent cracks, from unequal drying, but care should be taken to see that the area of the masonwork is of the required amount.

Footings are sometimes connected by wooden beams, as in Figure 11, but this method of construction should be used with great care, as it has a tendency to displace the center of gravity (as in Figure 12) of the pier, and violate the second principle laid down.

In order to get greater projection of footing, or more bearing-area, and that projection required to be had in a height that would be too great for ordinary offsets, iron rails or beams are sometimes used. The strength of these beams or rails can be calculated on the basis of a beam supported at one end with a distributed load. With such a mode of construction, the rails should be laid on a bed of concrete from twelve to eighteen inches thick, as an equalizer, and covered on top with cement. Such a mode of construction has the advantage of giving greater space in the sub-basement.

In ordinary circumstances, anchors, or tie-beams, are unnecessary to the stability of piers. The piers should be so designed that they will have a distinct and independent strength, and not dependent on each other for lateral support. It may be that tie-rods are neces-

sary to brace two parts of a building together, but this should not occur in a new building with independent walls, but may be in a new building adjoining an old one, where the walls have to be braced for various reasons, best determined when the case is before us.

Except under exceptional circumstances, piling in Chicago is an unnecessary and often a dangerous method of making a foundation, when we remember that below the blue clay we have about fifty feet of blue muck, which is incapable of sustaining the piles to any considerable extent.

On ordinary ground, away from the river, piling is unnecessary, from the fact that we have shown that foundations can be laid on top of the blue clay that will support the superstructure. If we conclude that piling is necessary, great care must be taken that a hard bottom is reached before the foundation is placed on top of the piles. This can only be got by driving through the clay and blue muck to the hard bottom below both, in all a depth of about fifty feet, involving very considerable cost and time in the construction thereof. It is supposed that by piling a given area, greater bearing surface can be got, hence greater stability. In some places this is the case, but not in Chicago, unless we go down to the great depth already stated. By piling a given area and placing the piles as close as convenient, say one foot apart, we at once reduce the bearing surface of the clay by just the area of the piles, and, supposing that the piles are driven through the clay and some feet into the blue muck (as in Fig. 13), we supply in place of the original clay surface a new bearing area equal to the area of the piles and resting on a highly compressible substance, the result being that when the load is put on, the whole foundation must inevitably sink, to the detriment of the building, resulting perhaps in cracks in walls, falling of floors, and other mishaps more or less disastrous.

Where piling is necessary is at the river bank, where water so percolates the soil as to render it highly compressible and spongy, and successful piling can only be got by following closely the conditions mentioned, namely, by driving to the hard bottom, to whatever depth that may be.

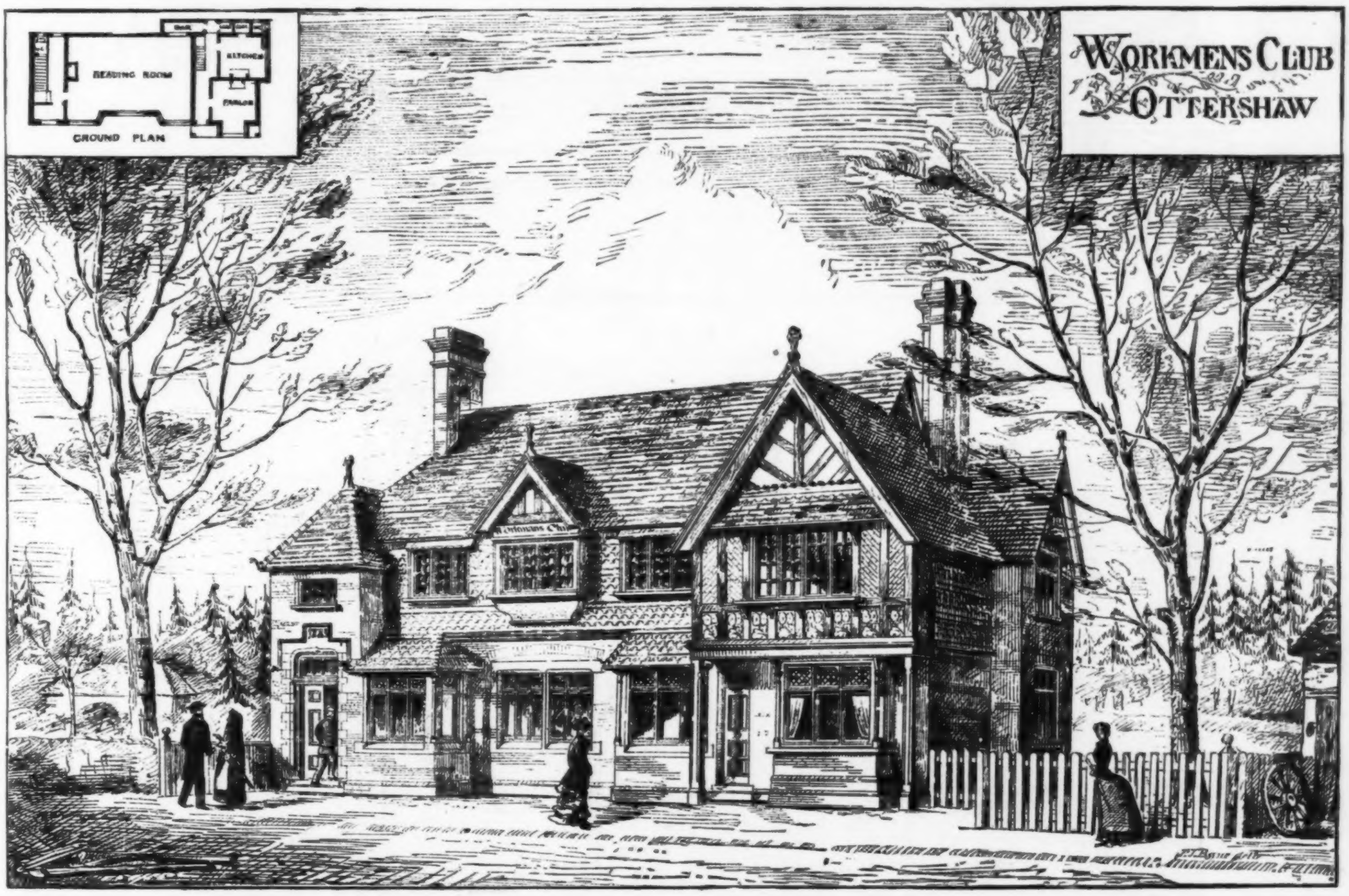
The Campanile tower of St. Mark's, Venice, is a notable and most successful example of an isolated pier being built on a highly compressible soil. We have it in the *American Architect*, of August 29, by Mr. Blackall, who examined the foundation, that "the total weight of the tower in round numbers is thirteen thousand tons, whence the distributed load on the piling is somewhat over six tons per square foot, a load which would cause modern engineers to hesitate a long time before putting upon piles which are simply driven into the clay. The foundations have, however, stood the test of several centuries without yielding an inch, and one of the most valuable results of the investigation has been to fix a maximum of load which can safely be borne under such conditions. It is an interesting question how much the piles really support, for as previously explained, they have no solid bearing, and, according to the manner in which piles are usually driven in Venice, could not be relied upon for such a load as six tons per square foot.

This is a very interesting question, but it appears evident that the piles must have been driven to the hard bottom; the exact depth we have no means of determining. The principles which hold good in one place hold good in another where the soils of both are compressible; and if, in Chicago, we have to drive to the hard bottom, so in Venice, to make a successful job, they have to do likewise.

Such, then, is a brief outline of what has to be done with foundations in Chicago. There are many other points not brought forward in this paper which are important enough to deserve a place of mention, but, as before stated, this paper is not an exhaustive treatise, but enough may have been said to spur our minds to a more active and intelligent understanding of the problems in foundations that may come within our daily practice; and the additional knowledge gained to-night will I hope be useful to all of us, and make us sympathize with those who have not been altogether successful in their undertakings, so far as foundations and equal settlements are concerned, and let us always be able to say, although not uncharitably, that, if any failure should occur in this connection it was the "other fellow" who suffered it.—*Read before the Chicago Architectural Sketch Club, Dec. 21, 1885; Sanitary News.*

WORKINGMEN'S CLUB HOUSE.

As a pleasing suggestion in architecture, we give an elevation of the new club house designed for workingmen, at Ottershaw, Eng. The architects are Messrs. Byrne & Wilmot, of Windsor. Our illustration is from the *Building and Engineering Times.*



A SUGGESTION IN ARCHITECTURE.

DIRECT FIXATION OF ATMOSPHERIC NITROGEN BY CERTAIN ARGILLACEOUS SOILS.

AT a recent sitting of the Academy of Sciences, Mr. Berthelot presented the result of some new and important experiments that he has made, and that have allowed him to demonstrate that the nitrogen of the air fixes itself upon certain argillaceous soils. Says the learned chemist: "There is no more interesting question in agriculture than that of the origin of the nitrogen of plants, which are themselves the primary source of the formation of animal tissues; and yet none has remained more obscure, despite a century of experiments and discussions. The nitrogenized compounds that concur in keeping up life traverse a continual cycle of transformations, during which some portion of their nitrogen is all the time returning to the elementary state. There must, then, exist inverse actions that are capable of fixing the atmospheric nitrogen. But the only action of this kind that has been known up to recent times—the formation of nitric acid by the electric spark—is manifestly insufficient. Thus, the nitric acid formed in the air in our climate in one year (1882–83) amounts to six ounces, according to observations made at Montsouris, while it would require from fifty-five to sixty-five pounds per acre to furnish the nitrogen removed by the annual crop of a meadow or by a forest. In truth, the spark also forms nitrite of ammonia by acting upon the moist nitrogen; but the weight of the ammoniacal nitrogen thus resulting from the decomposition of water would at the most be equal to the nitrous acid formed at the same time. In fact, it is inferior to it, since a portion of the nitric acid forms directly in the air from its free elements. The ingenious theory of the circulation of ammonia between the air, sea, and vegetable soil, proposed by Mr. Schloesing, would always allow the difficulty of origin to exist.

It was first thought that ordinary plants possessed the property of directly assimilating free nitrogen; but after long controversies and a host of experiments, the most recent authors and best authorities agree with Mr. Boussingault in rejecting this theory as being disproved by all accurate observations. Finally, the fixation of nitrogen by nascent hydrogen furnished by humus in decomposition has not been demonstrated either.

Meanwhile, a few years ago I demonstrated the existence of a new and unexpected cause of the direct fixation of free nitrogen upon the immediate principles of plants, and that was, not atmospheric electricity acting accidentally by those sudden discharges and those sudden sparks that form nitric acid and nitrite of ammonia during storms, but electricity, gradually engendering complex nitrogenized compounds through a slow, continuous action by virtue of the feeble tensions which exist at all times and in all places on the surface of the globe. In endeavoring to fathom this reaction, to which I shall again have occasion to advert, I have discovered another condition (which is also new and perhaps more general) of the direct fixation of atmospheric nitrogen; I refer to the hidden but incessant action of argillaceous earths and of the microscopic organisms that they contain.

My experiments were performed at the Meudon Station of Vegetable Chemistry, and were pursued for two years upon four different argillaceous pieces of ground. They constitute five distinct but simultaneous series comprising more than 500 analyses, to wit: a simple preservation of the material in a closed room; allowing it to remain under cover in a meadow; keeping it under cover at the top of a 90 foot tower; keeping it in hermetically sealed vessels; and, finally, sterilization."

After enumerating the long series of experiments, and giving the results of his analyses, Mr. Berthelot formulates the following conclusion:

"In short, the argillaceous soils studied, sands and kaolins, possess the property of slowly fixing the free nitrogen of the atmosphere. Such property is independent of nitrification as well as of the condensation of ammonia. It is attributable to the action of certain living organisms. It is not manifest in winter, but exerts itself especially during the season when vegetation is active. A temperature of 100° destroys it. It exerts itself in a closed vessel, as well as in contact with the atmosphere; in air entirely free at the top of a tower, as well as under cover near ground covered with vegetation, or in a closed room in the interior of a building. It takes place in darkness as well as in light, although more actively in the latter case."

This discovery of Mr. Berthelot's sheds a new light upon the question of the regeneration of natural soils, and his experiments at the same time explain how argillaceous sands that are almost sterile are, when brought into contact with the atmosphere, nevertheless capable of serving as a support and nourishment to successive vegetations, which flourish better and better because they utilize the nitrogen which is annually fixed by the sands, and that too from anterior growths that accumulate and become associated therewith, and so form in the long run a vegetable soil.—*La Nature.*

ACCORDING to the *Medical Abstract*, the discovery has been made in Colombia of a shrub which exudes a juice having so powerful an effect in arresting the flow of blood that large veins may be cut by a knife and smeared with it without causing hemorrhage. The plant is called "aliza" by the natives.

CRIMEA STREET DRAWBRIDGE, PARIS.

ALTHOUGH not yet the seaport that many speculators are ever dreaming about, Paris is nevertheless the city of France where tonnage figures highest, amounting, as it does, to more than four million tons per annum. Of this, a little more than two million tons comes by way of the Seine, while the rest is brought by the Ourcq, Saint Martin, and Saint Denis canals.

From the year 1529, the Ourcq River, which issues from the Retz forest, a little above Fere-en-Tardenois, and falls into the Marne below Lizy, has been the object of numerous canalization operations, due to the capital's need of wood for fuel and building purposes. Although his project could not be carried out, it was Riquet who first conceived the idea of bringing water direct to Paris by a canal that was to serve both as a supply and for navigation. In 1785, Engineer Brullee proposed to the Academy of Sciences to tap the Beuvronne in order to feed a canal connecting the Arsenal basin with Saint Denis, but the crises of the end of the last century put an end to the scheme. It was not until under the consulate that these two conceptions were united by a law that prescribed the opening of a canal of continuous slope, to bring the entire water of the Ourcq into a basin that was to be excavated at La Villette, as well as of a canal starting from the Seine below the Arsenal basin, traversing the latter, and continuing upon Saint Denis.

The Ourcq Canal, which was the first one begun, was, in principle, to serve only as a supply, but in 1805 the Emperor decided that its profiles should be so established as to give passage to boats of medium size. The Villette basin was finished in 1808, and navigation was opened between Claye and Paris on the 15th of August, 1813. The Saint Denis Canal, which was begun in December, 1811, was finished May 13, 1821. The Saint Martin Canal was begun March 1, 1822, and finished December 23, 1825.

Since their construction, numerous important works, and especially those of recent years, have continued to improve these three routes, whose conditions of navigability are so intimately connected with those of the Seine. We give herewith a description of one of these works, the new Crimea Street drawbridge.

Earthwork and Masonry.—Crimea Street forms the bar of the A which Flanders and Germany Streets make. The old revolving bridge over which this street crossed the canal left a passageway of but 25½ feet to boats, and the depth was only 6½ feet. These dimensions became entirely insufficient after the improvement of the lower Seine, and the city of Paris therefore resolved to widen the pass to 49 feet and to make the depth 10½ feet. The execution of the work was confided to Mr. Le Chatelier, under the direction of Engineer-in-Chief Humblot, and with the assistance of Mr. Briotet.

One great difficulty in the way of the project was that the subsoil of the street gave passage to a collector of large dimensions, which, in addition to telegraph, telephone, and pneumatic lines, contained two 16 and 24 inch conduits, and the extrados of the arch of which was on a level with the bottom of the canal. It became necessary, then, to lower this archway about a yard, while at the same time preserving the level of the drain, so as to avoid the construction of a siphon. It was therefore decided to have recourse to two conduits (thus permitting of a notable reduction of the joined sections), one to be set apart for the water and the other for the accessory services.

Profiting in all haste by the standstill of 1884, dams were constructed above and below the abutments of the old bridge, thus forming a working space that could be pumped dry. The cessation of operations on the canal lasted but nineteen days, but in this short interval the two new galleries were carried from shore to shore, although the junctions and the mounting of the parts of the abutments that profiled upon the returns in which the counterpoise wells were to be situated were not effected until later. At this point the excavation was carried to a depth of 23 feet below the plane of the water.

The dams were constructed of two lines of piles and planks, the 5 foot space between which was filled in with puddled clay. Only every other pile was braced, yet this sufficed to make the system perfectly firm. The tightness of these dams was such that after the water had once been removed, it required but a pump that discharged 2¼ to 3 gallons per second to keep the sewer excavation dry.

The programme was carried out to the letter, and the regular cessation of operations on the canal was not prolonged a single day. Navigation, which was interrupted on the 29th of June, began again on the 18th of July, the use of the bridge meanwhile not having been interfered with.

The two sections that prolong the central well, on each side, were driven by means of shafts sunk back of the abutments of the old bridge; but this work was effected only at the cost of difficulties still greater than those that had been met with in the first part of the operations.

Meanwhile, the junction having been reached, it became necessary to work in the open air. Travel was interrupted at this point, and transferred to one beyond, through the construction of two temporary walks—a bridge for pedestrians and another for carriages. Navigation remained free. The foot bridge had an opening of 100 feet between the two stairways at each end, and its width between the hand rails was 4¾ feet. The carriage bridge was established at the height of Evette Street. It consisted of two framework buttresses that received the ends of a movable bay, with two roadways, formed of four iron girders, that supported a wooden flooring. To maneuver the bridge, this bay was lifted by means of three jack-screws, carried by two boats, with which it was connected in such a way as to allow of none but a vertical motion. When the entire affair had been lifted, it was turned in the direction of the pass, so as to leave a free passage for boats. In this way the third phase of the substitution was terminated without interfering with travel.

In order to finish the new sewer, it only remained to apply the facing to the extrados of the tunnel crossing the canal. The cessation of navigation in 1885, which lasted but eight days, was of long enough duration to allow of this operation being performed, of the old abutments being demolished, and of the removal of that portion of the dams that had been used in the construction of the new bridge.

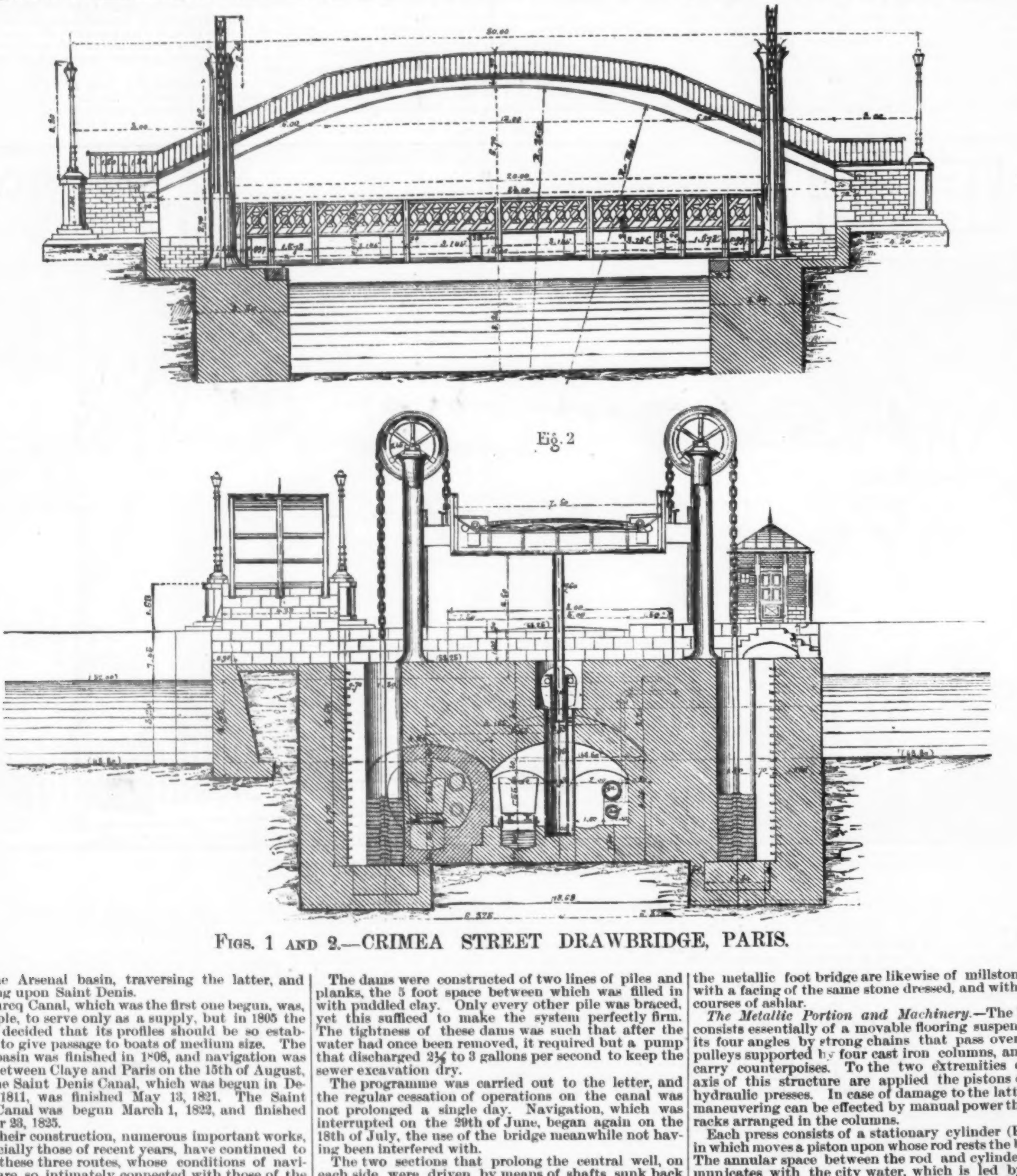
And now a word as to the composition of the masonry. The abutments, as well as those portions of the sewer that traverse them, are constructed of millstone grit, with mortar composed of one part of Portland cement to four parts of sand. The facing, both external and internal, is made of a mortar containing two parts of sand to one of cement. The abutments of the metallic foot bridge are likewise of millstone grit, with a facing of the same stone dressed, and with angle courses of ashlar.

The Metallic Portion and Machinery.—The bridge consists essentially of a movable flooring suspended at its four angles by strong chains that pass over guide pulleys supported by four cast iron columns, and that carry counterpoises. To the two extremities of the axis of this structure are applied the pistons of two hydraulic presses. In case of damage to the latter, the maneuvering can be effected by manual power through racks arranged in the columns.

Each press consists of a stationary cylinder (Fig. 2), in which moves a piston upon whose rod rests the bridge. The annular space between the rod and cylinder communicates with the city water, which is led by conduits to the upper and lower parts of the piston. As the movable part of the bridge is exactly balanced by the counterpoises, the motive power to be developed in order to set it in motion has nothing to overcome (aside from the weight of the chains) except friction.

The two presses are identical and conjugate, and work simultaneously through the action of a single one of two gears. The entire mechanism is so simple that but little stress is necessary to work it. The distributing apparatus are placed on each side of the canal, in small buildings erected on the abutments.

Despite the precautions taken to secure, as far as



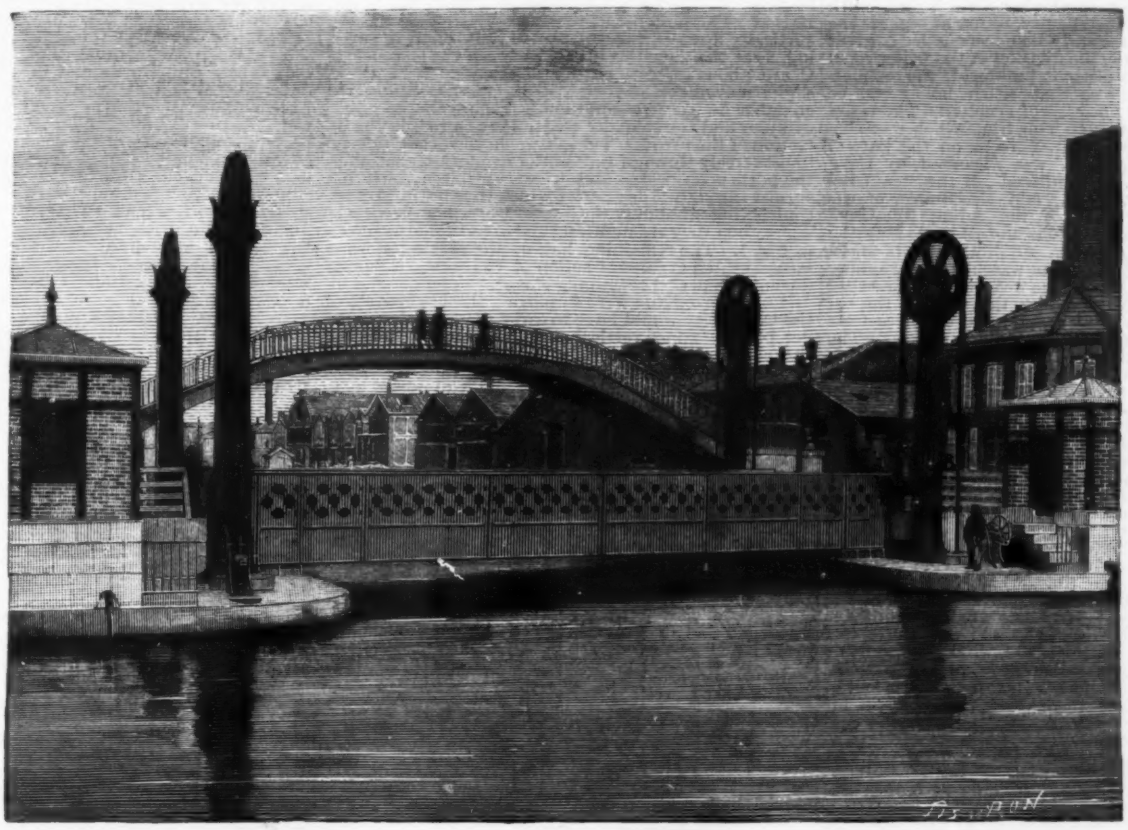
FIGS. 1 AND 2.—CRIMEA STREET DRAWBRIDGE, PARIS.

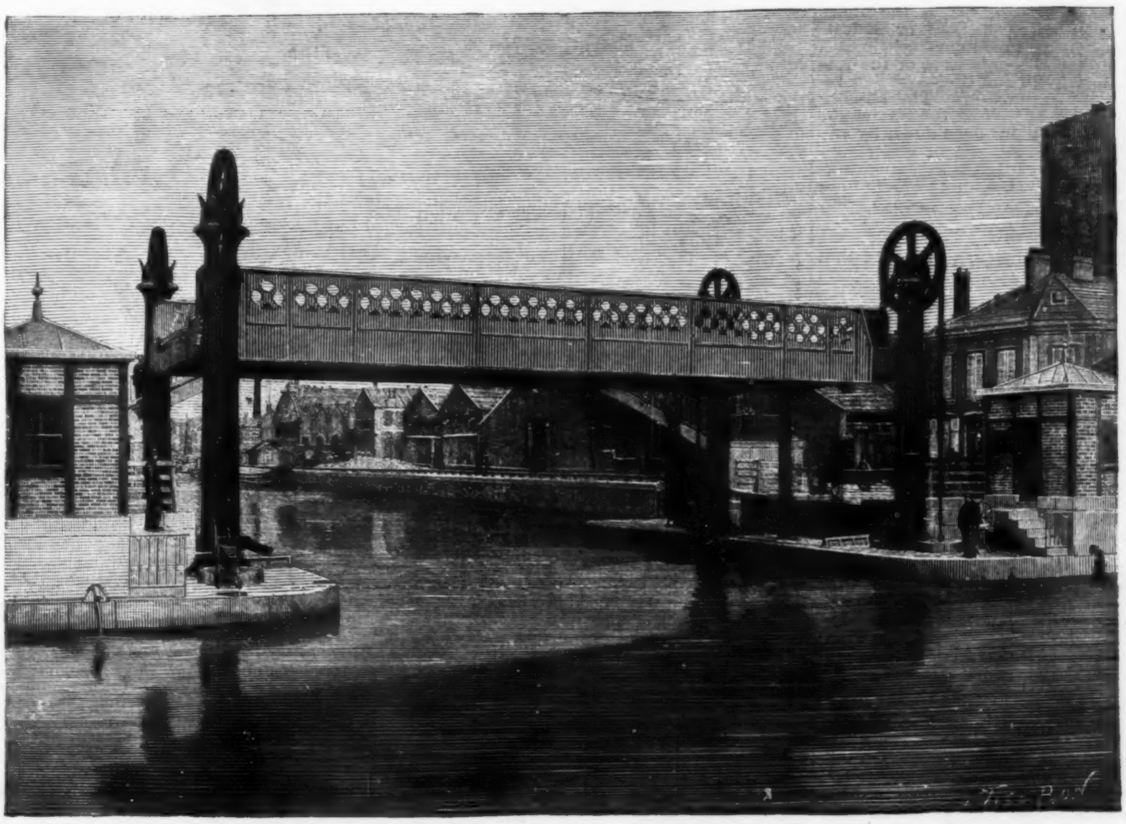
possible. an equality in the stresses transmitted to each end of the bridge, it was not possible to obtain an equal distribution of the load upon the presses, and it was therefore necessary to secure a perfect parallelism of the bridge's motions, and render the motions of the four apices of the parallelogram interpendent. This was done by the following arrangement: At each extremity of the bridge there is a transverse shaft to which are keyed two cylindrical toothed pinions that gear with a rack fixed in a depression in the corresponding column. These two shafts are actuated through the intermedium of a third longitudinal shaft, and of conic pinions. This latter shaft rests upon the cross pieces of thick. The walks for foot passengers are at the sides. The total length of the bridge is 65 feet, and its total width 25. The roadway is 17 feet in width and the foot paths 4 feet.

The total weight of the work is 538,747 pounds, in which the movable part comes in for 171,700.—*Le Genie Civil.*

A TORPEDO CATCHER.

THE construction of torpedo catchers was as much a necessity in naval warfare after the development of the torpedo system of small, quick-steaming torpedo craft pinnaces and launches and in various submarine miners, built for the Royal Engineers, had not previously been adapted to first-class torpedo vessels. During the past four years we have on various occasions noticed the gradual development of the invention of Mr. John Samuel White, of East Cowes, which is now popularly known in the service as his "turn-about" system. Boats built according to this plan have their deadwood removed in order to obtain facility in turning, and are fitted with an inner and outer rudder, simultaneously actuated, either of which would suffice to steer the vessel in the event of the other being lost or disabled.





FIGS. 3 AND 4.—CRIMEA STREET DRAWBRIDGE, PARIS.

the bridge itself. As for the other two, they are supported by two transverse girders whose extremities end near the columns, and terminate in bearings in which revolve the guide pulleys.

The bridge proper presents one new and interesting arrangement. Usually, in movable bridges, there are two roadways with an intermediate pathway for pedestrians. Such a system is not very elegant, and, besides, in case of repairs, necessitates all travel being transferred to one of the two roadways. After experiment, Mr. Le Chatelier has substituted a continuous roadway of embossed iron plate for beams, and over this has spread a compound of coal pitch and sawdust upon which he has laid a wooden pavement four inches

as armored protection for battle ships became in consequence of the growth of the gun. The catchers, or police of the sea, do not differ, except in bulk and speed, from the active and dangerous little enemies which they are intended to capture and destroy; and in this respect the Admiralty would appear to have applied the old detective principle of setting a thief to catch a thief. The first of the new craft yet afloat was tried in Stokes Bay, near Portsmouth, recently with remarkable results, not only as regards speed, but also as regards maneuvering power. This latter quality of the torpedo catcher was even more noteworthy than the former, and has been secured by the application of a principle which, though successfully tried in steam

The present experimental torpedo boat was undertaken by Mr. White for the purpose of demonstrating the applicability of his invention to larger vessels, and with a view to her acceptance by the Admiralty on her fulfilling all the conditions guaranteed. She is considerably larger than all the existing torpedo craft in Her Majesty's Navy, being 150 feet long, 17 feet 6 inches broad, and 9 feet 6 inches deep. Her displacement is about 125 tons. Her lines resemble those of similar vessels now in use, but she is fitted with a turtle deck and a spur ram. Like the others, she is built of thin steel, and has a conning tower amidships, from whence she will be steered in action. Messrs. G. E. Belliss, of Birmingham, the makers of all the

machinery of Mr. White's boats, joined with him in the undertaking, supplying compound engines of the three-cylinder type, the high-pressure cylinder being 20 inches and the two low-pressure cylinders 24 inches in diameter, the whole being supported on light steel columns. The stroke is 18 inches. Great care has been taken in the design to keep the weights as low as possible, having due regard to efficiency. There are two air pumps driven off the low-pressure crossheads, while the feed pumps are driven direct from the crankshaft. Steam is supplied by two locomotive boilers, with the feeds so arranged as to insure an equal supply of water to each boiler; and, as the result of the trial, the possibility of successfully employing two boilers with forced draught without difficulty, either as regards the feed or priming, was clearly demonstrated. A great feature in the design is the division of the boiler-room by a longitudinal water-tight bulkhead, the connections being arranged so that either boiler can be worked independently in case of accident. The vessel is also steered by steam. The trial, which was conducted by Mr. White and Mr. Morcom, on the part of the builder and engineers, was witnessed by Commander the Hon. F. R. Sandilands, of the Steam Reserve, Mr. T. Soper, R. N., and Mr. Smale, of the Comptroller's Department of the Admiralty; Chief Inspector of Machinery Alton, and Messrs. Mayston and Gowing of the dockyard. Admiral Herbert and a number of naval officers also watched the running from the deck of the Camel. The weather was somewhat boisterous, but nothwitstanding the state of the sea the vessel was remarkably steady, and also free from vibration, when going at her maximum speed. The total weight on board was 25 tons, 15 tons representing coal and 10 tons (furnished by iron ballast) her armament of Whiteheads and rapid-firing guns. Provision, however, has been made for carrying 35 tons of coal in the bunkers, while the space forward and aft for the accommodation of officers and crew and stores is unusually large. Six runs on the measured mile were first made for the purpose of ascertaining the speed under the special conditions of load, which resulted in the realization of a mean speed of 20·79 knots, the mean boiler pressure being 126 pounds, the revolutions 319 per minute, and the indicated horse-power 1,387. The highest speed in the direction of the wind was 22·43 knots, and the following times which it took to complete the miles will show the regularity with which the speed was maintained: With the wind, 2 minutes 43 seconds, 2 minutes 40½ seconds, and 2 minutes 40½ seconds (repeated). Against the wind, 3 minutes 9 seconds, 3 minutes 7 seconds, and 3 minutes 5 seconds. The average indicated horse-power per square foot of grate was 23, which was maintained with a mean air pressure in the stokeholes of 2¼ inches, which was considered a very high result. The vessel was afterward tested in the usual manner for maneuvering power. At full speed, with the helm hard over 30 degrees, the starboard circle was completed in 1 minute 17 seconds (238 revolutions of the engines), and the port circle in 1 minute 12 seconds (270 revolutions). At half speed the starboard circle was completed in 1 minute 14 seconds (237 revolutions), and the port circle in 1 minute 15 seconds (246 revolutions). The diameter of the circles was about a length and a half of the boat, or 225 feet. The craft was finally run for three hours' continuous full-power steaming, to test the endurance of the mechanism. No mishaps occurred, and the speed and revolutions were maintained throughout. The absence of vibration during the trial, as well as the very slight inclination on the helm being put hard down by the steam-steering engine, was the subject of general remark, and Mr. White and Messrs. Belliss were congratulated at their joint success in the building and engining of what is regarded as the best type of torpedo catcher.—*London Times.*

ROTARY ENGINES WITH MOVABLE PARTITION.

Rotary engines of this character are very numerous, and seem, at first sight, to offer the solution of the problem of producing a direct turning movement of a shaft by the action of steam or other pressed fluid. An engine of this character was devised by Watt, a contrivance which consisted of a radial piston attached to the revolving shaft, and which was made to extend the whole length of a cylinder and revolve within it, its outer edge touching against the barrel of the cylinder. To obtain a steady piece against which the steam might react in its effort against the piston, a partition piece was introduced of such a character as to revolve about a longitudinal axis in the cylinder barrel, so as to allow the piston to pass freely when coming up to it, but so arranged as to drop down with its edge against the revolving shaft after the piston had passed.

An engine on similar principles has been invented by Mr. John Pinchbeck. The broad character of the Pinchbeck engine is not unfamiliar, but the ingenious combination by which the working pieces mutually support each other in preserving secure joints is one of novelty, and one which greatly adds to its efficiency. The main mechanism is an eccentric cylinder revolving with a shaft whose axis coincides with that of a larger and fixed cylinder in such a manner that the outer edge of the revolving cylinder is always in contact with the interior surface of the fixed cylinder. The eccentric piece, A, is always pressed against by a sliding piece, B, a piece extending the whole length of the cylinder, and constrained by appropriate guides to move radially to the fixed cylinder. The eccentric itself causes this piece to rise, the downward movement being produced by an external force. Effectually to complete the combination, an intermediate piece, C, is introduced, and paired as shown by fair cylindrical surfaces to the steadied pieces, A and B.

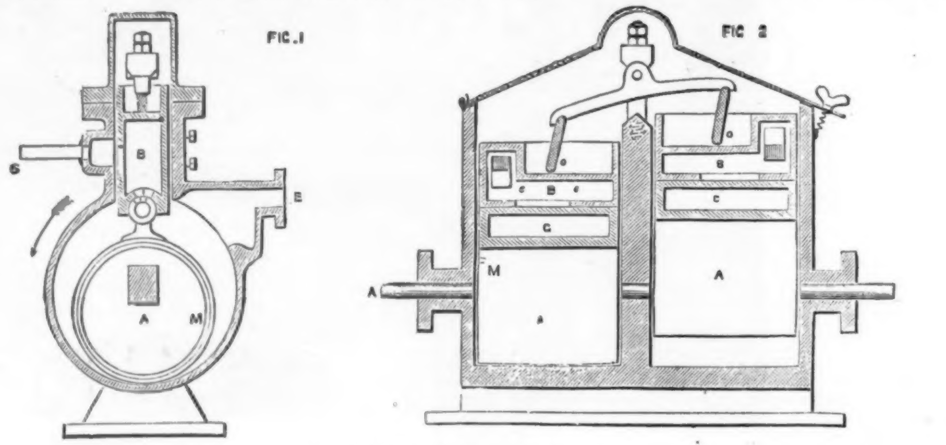
If this mechanism be set in motion by turning the shaft, A, connected to the eccentric cylinder, A, the two chambers into which the partition, B, divides the space between the eccentric piece and the cylinder in which it works become alternately expanded and contracted. Steam being admitted to the expanding chamber and allowed to exhaust from the contracting one, the contrivance is set in motion.

This distribution of steam is carried out in a novel manner. In many of these engines this is obtained by channels cut in one of the steadied pieces working against a surface in the fixed frame provided with suitable steam and exhaust ports. In this case the ports are constructed in the intermediate piece and in the moving piece with which it is jointed. The cylindrical part of C is hollow, and is perforated as shown by the black spaces, these perforations extending from *c* to *c*, as indicated in Fig. 2, a longitudinal section. Similar spaces are provided in the lower part of B, which is also hollow to allow of the steam passing through to them. Steam enters by the pipe, S, into the casing inclosing B; the orifices cut in the side of B, facing this pipe, must evidently be of such a depth as never to obstruct the flow of steam in its reciprocation. The exhaust channel, E, is situated on the other side of the partition. To complete the steam entry arrangements, a perforation is made from the hollow of C, leading into the left-hand chamber. When the block, B, is at its highest point, the eccentric arm of A being vertically upward, the steam is on the point of entering, as at this time the blanks between the channels of C are about to cease blocking the channels in B. A slight movement and the steam enters, filling the chamber to the left, and forcing round the eccentric cylinder and the shaft to which it is secured, in the direction of the arrow. The steam on the other side exhausts freely through E. As the revolution continues, the ports open wider and wider, until the shaft has turned through 45 deg., after which they begin to close, contracting gradually until the angle has become 90 deg., when they close entirely and are situated as shown in Fig. 1. The remaining half of the revolution is obtained by the expansive action of the steam, the ports during this period remaining closed.

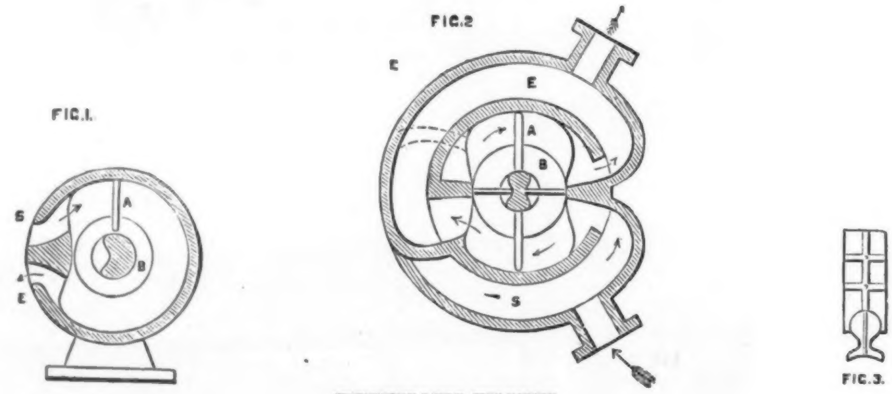
If a single engine were employed, the momentum of the machinery would have to carry the revolving cylinder past its upper vertical position, as in this position the chamber is not divided by the partition. The peculiarity of this engine lies, however, in the use of two cylinders, not so much to avoid dead points as to obtain a mutual action between the reciprocating blocks. The second cylinder and its mechanism are so disposed that the upward movement of the block in the one engine carries out the downward movement of the block in the other, a suitable lever connection being employed. This second engine and the arrangements of its parts can be seen from the longitudinal section, Fig. 2; the fittings are the same as in the other, but so placed that when one reciprocating block is up the other is down. The connecting mechanism alluded to consists of a lever rocking about an adjustable fulcrum, O, the ends of the lever being paired to intermediate pieces, O¹, which are in their turn paired to the sliding blocks. It can easily be seen how this arrangement carries out the idea of causing the reciprocating block to follow the eccentric cylinder in its downward movement. And it will also be observed that the jointing is such that when wear has taken place all the parts are adjusted up to their work again by screwing down the fulcrum, O. It is true that in this case four distinct groups of mechanism are employed—the two eccentric cylinders with their sliding blocks and intermediate connecting pieces; the two arms of the lever with their intermediate links paired up with the reciprocating blocks. This does not, however, apparently much complicate the construction, and certainly does a great deal toward keeping down wear and keeping up steam tightness in this particular class of engine.

A good many joints require attention in this engine. There are the fronts and sides of the reciprocating block; the connections of the intermediate piece, C, with the reciprocating block, with the surface of the eccentric cylinder, and with the sides of the fixed main cylinder; also the jointing of A with the inner surface of the fixed cylinder and with its flat ends. The large faces of the sliding blocks work against a flat plate, shown on its right in Fig. 1, which can be adjusted by set screws; the ends have cross strips of metal fitting in corresponding recesses, and kept up against its surface by springs behind, shown in Fig. 3. The port faces or connection between the pieces, C and B, are accurately fitted, the ends of C having strips kept against the rubbing surface by springs, as indicated in Fig. 3. The face of this piece toward the turning cylinder is well fitted, this, as well as the port face, being kept up to its work by the external force acting on the reciprocating piece above, derived from the action of the neighboring engine. The touching surface between the eccentric cylinder and the fair cylinder is rendered effectual by making the connection between this cylinder and the revolving shaft square, the shaft being forged square and passed into a square hole in the cylinder. A little play being purposely allowed, set screws are so placed as to set the revolving cylinder outward against the fixed. A fair surface contact is obtained here because of the similar curvature. For the sides of this piece metallic rings, *m*, are fitted in annular grooves running around the ends as near to the outer edge as possible, and kept against the sides of the fixed cylinder as with the packing of an ordinary piston. To prevent dirt obtaining access to the working parts, the upper part of the machine is closed by a light cover. An engine of this description with 8 in. cylinders will develop a brake horse-power of about five, running at 450 revolutions, with a steam pressure of 45 lb. on the square inch. With duplicate valve gearing and duplicate steam and exhaust channels, this engine can be made reversible.

The Bennison engine, which is manufactured by the same firm as the previous engine, Messrs. R. Waygood & Co., may be said to be in some respects the converse of the Pinchbeck engine. In the Pinchbeck engine, the sliding partition is moved in a fixed frame by the revolution of an eccentric cylinder; in the Bennison, the sliding partition is moved in a revolving frame by the action of a fixed eccentric piece. The simple movements of this engine can be seen from Fig. 1. A fixed cylinder is so shaped that a radial partition, A, while revolving about its axis, is compelled to take an eccentric course. To accomplish this completely, an inner fixed cylinder is shaped so as to have a similar eccentricity with the outer, there being a constant radial distance between them. Turning on this central cylinder is a cylindrical piece, B, whose outer surface touches that part of the outer cylinder which penetrates farthest into the interior. The piece, A, is paired with the piece, B, by means of a longitudinal slot in B, to allow of A sliding in and out as it is acted upon by the fixed eccentric surfaces. This formation extends the whole length of the cylinder. Upon turning the shaft, B, the chamber between one side of the partition, A, and the fixed eccentric abutment from the large cylinder increases, that on the other decreasing. Suitable steam and exhaust channels being provided at S and E, one chamber is expanded by the action of the steam, the other being opened out to exhaust, the consequence being that the piece, A, is forced round, carrying with it the shaft piece, B. As A comes up on the other side of the eccentric abutments it sinks back into B, reappearing as it comes out on the other side; the above action is then repeated, and continuous rotation kept up. The actual Bennison engine differs from this in having four rotating sliding blocks, two opposite eccentric abutments on the same cylinder, and in having the steam and exhaust passages so disposed as to well balance the machine when at work. If used as in Fig. 1, there would always be a considerable axial pressure—a pressure caused by the unbalanced steam force on A pushing the drum, B, hard against the axle passing through it. This force causes a considerable amount of wear in the axles or bearings of many engines, an action which might be termed a reamering out of the bearings. By placing four sliding pieces, A, equidistant around the revolving piece, B, the ports being arranged as shown, so as to admit steam on opposite blades, and exhaust from opposite blades, it is clear



PINCHBECK'S ENGINE.



BENNISON'S ENGINE.

that the axle, having equal opposite forces on either side, is relieved from any pressure. No separate valve gear is employed; the revolving blades or pistons passing the ports cause the steam to act upon them at the proper time. The several joints are not generally fitted with special packing arrangements for preserving tightness. The ends of the blades, where pairing with the fixed cylinder, are rounded and touch home as they revolve, an extra security resulting from the centrifugal action set up forcing them out against their working surface. Where the blades pass into the drum the surfaces are flat and accurately fitted, a treatment which appears to secure proper tightness. The joint is aided greatly in the peculiar action of the engine, which is such that when the steam is exerting a force on one side a blade, this being the case when it is moving through the upper and lower quarters between the eccentric abutments, the blade is stationary toward the turning drum, and is held against the side of the slot by the force of steam, thus assisting to keep it tight. As the blade passes the abutments there is an equal pressure on both its sides, as at this time it is passing a port; it is therefore free to pass into the slot by the action of the abutments, and no leakage can occur, as the pressure on each side is the same. Similar remarks apply as it passes outward, after turning past the extreme position. The power exerted by this engine is fairly large for its size, a result due to the fact that one revolution of the shaft gives opportunity for two cylinder volumes of steam to do work. There being four blades, each of which is acted upon through two quarters of the cylinder in a revolution, the aggregate volume swept through is evidently twice that of the cylinder. This engine is as much used as a pump as a motor; a 14 in. pump delivering over 1,000 gallons of water, while running at 200 revolutions per minute; and this water delivered, as might be deduced from the examination of its construction, in a steady stream.—*The Engineer.*

TELEPHONY AT THE PHILADELPHIA EXHIBITION.

Electrical Transmission of Time.—In the Western Electric Co.'s department, at the late Philadelphia Electrical Exhibition, Mr. Oram exhibited a small apparatus that is placed in a central telephone office for giving subscribers the exact time.

This apparatus sends interrupted currents over the entire line every minute. These are so weak that they do not interfere with conversation, but are sufficiently strong to produce quick, short, very distinct sounds that are separated by regular intervals. The subscriber, in order to know what time it is, has only to unhook his telephone and put it to his ear. Every minute he hears a feeble murmur that warns him to pay attention, and immediately afterward he hears successive interruptions that give the hour and minutes. To make this clearer, suppose he has heard two blows followed by a short interval, then three blows and an interval, and finally seven blows. These signals indicate to him that at the moment of the next signal, that is to say, in one minute, it will be two o'clock and 37 minutes.

The complete apparatus consists of a clock which gives a contact every minute, and which runs the distributing apparatus shown in Fig. 1. V is a relay which forms a contact every minute when the current is sent to it from the clock. The forming of this contact throws the drum into gear with the electric driving axle, M, which, supplied by a special pile, is always in motion.

Upon the surface of the drum there are fixed, as upon the drum of a music box, several series of pins, representing the hours, ten minutes, and minutes. These pins, during the revolution of the drum, actuate the lever which carries the hammer, Q, and this latter, during one revolution of the drum, strikes as many blows as there are active pins upon the circumference. This hammer establishes a contact every time for a special pile, and a current of short duration is sent over the line. By a very simple process, another series of pins acts every minute upon the lever, so that one blow is added at every new minute. After nine blows there is a totalization, and the tens of minutes are increased. The same operation is produced automatically for the hours. There is no need of describing all these details, as the figure explains them sufficiently well.

The electric motor is very simple. In front of the poles of a horseshoe magnet there are two bobbins that carry a commutator on their axis. The motions of this motor would be too rapid to actuate the drum directly, and this is why there is interposed between the two a clockwork movement that produces a retardation.

In order to render the thing clearer, we give a diagram of the communications in Fig. 2. H is the clockwork that forms a contact at every minute and sends a current into the relay, A. The armature is attracted and the drum is set free. At the same time, a small metallic disk, C, mounted upon a spring at the end of the armature, touches the screw, B, for a moment and repeats the contact several times as a consequence of the vibrations that are communicated to it by the shock. Every time there is a contact between B and C the current from the pile, P', passes through B and C, the armature, L, and afterward through G and V, over all the lines of the subscribers that end in one common ground. To this effect, the communication of the tablet with the earth, *t*, is detached. Then all the subscribers who at this moment have their telephone at the ear hear the murmur derived from a series of rapid contacts between B and C. Practice has shown that the separation from the earth presents no inconvenience for the central office, and that consequently the earth can be taken upon the lines running to all the subscribers.

The motion of the armature, L, of the relay, A, sets in motion the drum whose pins cause the hammer, T, to strike the contact, S, and the number of blows given corresponds to the hours and minutes indicated by the clock, H. At every blow of the hammer a contact is established between T and S, and the current from the pile, P'', passes through T, S, G, V, upon all the lines. Each contact is of but short duration. A very decided sound is heard in all the telephones that are unhooked from their commutators, and all the hammer strokes can easily be counted.

The National Time Regulating Co., which is working this apparatus, charges subscribers one dollar a year. In practice, one difficulty was met with which has been surmounted in a very simple and ingenious manner. It was found that when signals were being transmitted to subscribers who paid their annual dues, many others in the circuit heard the transmission gratis, and that too without their wire being connected with the Oram apparatus. This was the well known effect of induction. To prevent non-subscribers from knowing the time by telephone, another hammer, R (Fig. 2), has been added that gives additional signals which produce a confusion. To this effect, all the lines, *s*, *s'*, *s'*, etc., of subscribers who do not pay for the time are connected with each other after passing through the communicator tablet, and are put in communication through a pile, P', with a "confusing" hammer, R. The drum runs this hammer at random, and at every blow a current is sent over the line that produces a noise which is made as like as possible to the regular sound that is heard through induction from the true distribution.

Various Telephones.—Among the telephones exhibited, we found a few apparatus that differed slightly from the form generally used in the United States. Among others, the Eaton apparatus (Fig. 3), the magnetic field of which is formed by a series of small magnets whose poles of like name enter the bobbin, while the others surround it externally. The Graham telephone (Fig. 4) differs from the preceding only in the bobbin being mounted upon a spring, and being consequently movable between the poles of the magnet.

In the Baxter receiver (Fig. 5), the extremity, F, of the horseshoe carries two concentric bobbins, *b* and B. The annular interval is filled by a soft iron tube. The inventor doubtless intends by this means to re-enforce the magnetic action. The transmitter is shown in Fig. 6. The variable contact is connected with a rod, T, movable around the points, O O, and held at its lower extremity by an electro-magnet, B, placed in the circuit of the microphone pile.—*La Lumiere Electrique.*

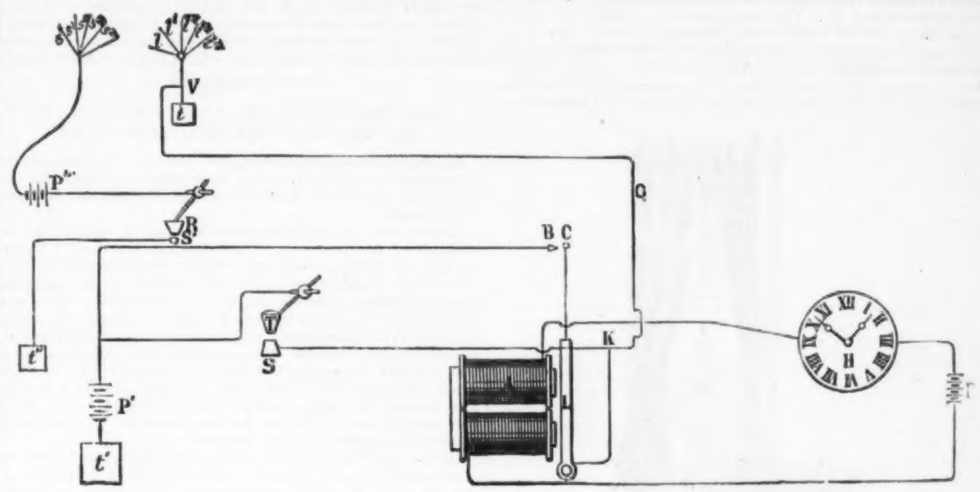


FIG. 2.

FIG. 3.—EATON'S TELEPHONE.

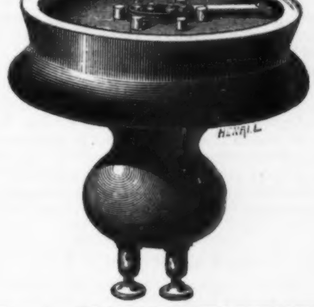


FIG. 4.—GRAHAM'S TELEPHONE.

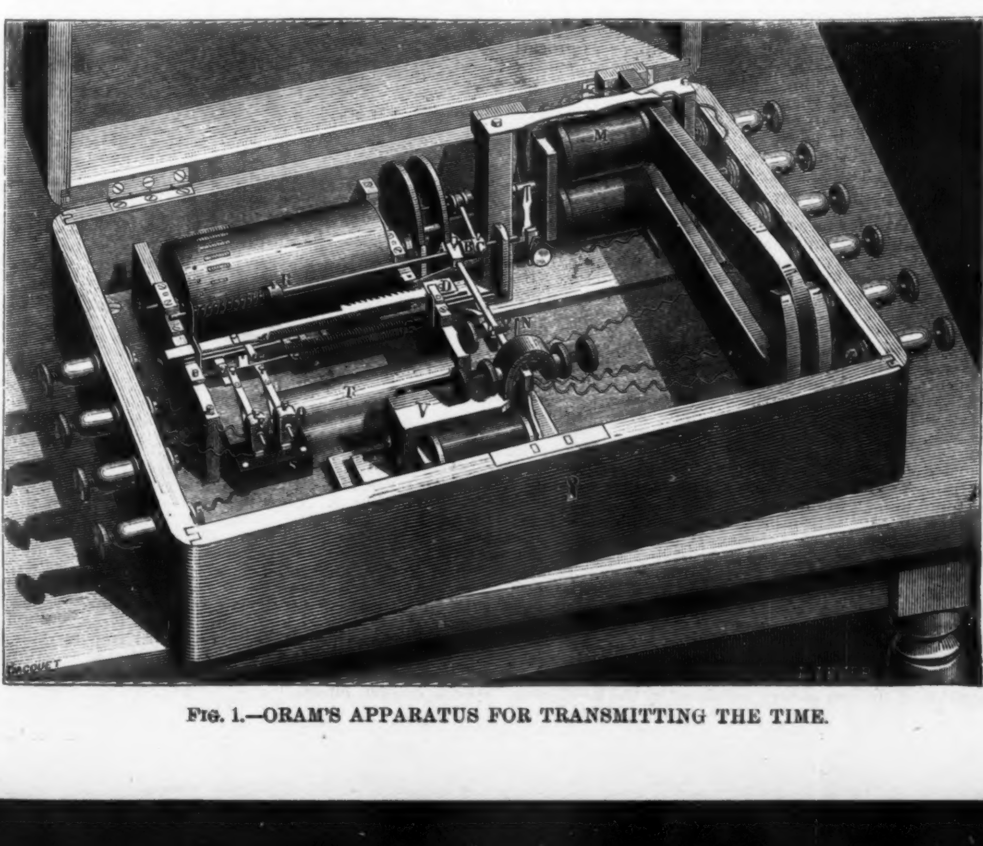
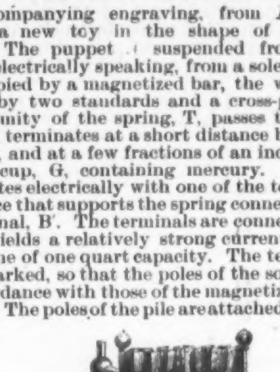


FIG. 1.—ORAM'S APPARATUS FOR TRANSMITTING THE TIME.

FIGS. 5 AND 6.—BAXTER'S TELEPHONE.

A NEW ELECTRIC TOY.

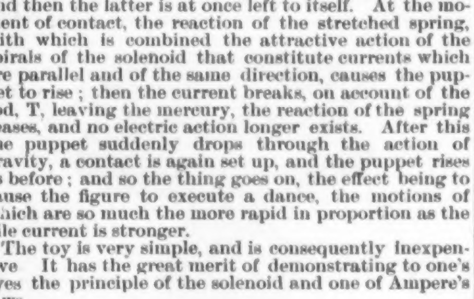
The accompanying engraving, from *La Nature*, represents a new toy in the shape of an electric danseuse. The puppet is suspended from a spiral spring, or, electrically speaking, from a solenoid whose axis is occupied by a magnetized bar, the whole being supported by two standards and a cross-piece. The lower extremity of the spring, T, passes through the puppet and terminates at a short distance beneath the latter's feet, and at a few fractions of an inch from the level of a cup, G, containing mercury. This latter communicates electrically with one of the terminals, B, and the piece that supports the spring connects with the other terminal, B'. The terminals are connected with a pile that yields a relatively strong current, say a bichromate one of one quart capacity. The terminals are properly marked, so that the poles of the solenoid shall be in concordance with those of the magnetized bar that traverses it. The poles of the pile are attached respectively to each of the terminals that carries the sign of their notation. The pile is set in action, the end of the rod, T, is plunged into the mercury by pressing down the spring, and then the latter is at once left to itself. At the moment of contact, the reaction of the stretched spring, with which is combined the attractive action of the spirals of the solenoid that constitute currents which are parallel and of the same direction, causes the puppet to rise; then the current breaks, on account of the rod, T, leaving the mercury, the reaction of the spring ceases, and no electric action longer exists. After this the puppet suddenly drops through the action of gravity, a contact is again set up, and the puppet rises as before; and so the thing goes on, the effect being to cause the figure to execute a dance, the motions of which are so much the more rapid in proportion as the pile current is stronger.



The toy is very simple, and is consequently inexpensive. It has the great merit of demonstrating to one's eyes the principle of the solenoid and one of Ampere's laws.

KENDALL'S GENERATOR OF ELECTRICITY.

Among the new apparatus that figure in the section of electricity, at the Exhibition of Inventions, the generator of Mr. Kendall, of North Ormesby, York, is certainly one of the most interesting. In this apparatus a current of electricity is produced by means of a current of hydrogen at a high temperature. Each element consists of two platinum tubes, one within the other and impermeable to liquids. Between the tubes melted glass is poured. When a pile of several elements is in operation, the internal tubes are constantly filled with hydrogen, while the entire apparatus is kept at a very high temperature by means of a furnace fed with coke or any other fuel. The hydrogen is absorbed by the internal tubes, and a current of electricity is produced which is collected by the conductors connected with the platinum tubes. Upon traversing the metal of the internal tube, the hydrogen is separated from all the gases with which it is mixed, so that there is no need of using pure hydrogen. The gases thus lost may be used for heating, provided they are combustible.



KENDALL'S GENERATOR OF ELECTRICITY.

The cut represents an element of this kind. AB is a section of a Fletcher blast furnace for heating the tubes. C is the internal platinum tube, and D the inner one. E is a glass tube with orifice, F, to allow the gases to escape. G is a platinum tube for the passage of the hydrogen. H is a bent tube for leading the hydrogen. JJ are conductors for collecting the current produced. K is the glass that separates the platinum tubes.

The electromotive force of a single element is 0·7 volt. In practice, a certain number of elements is grouped together and heated by the same furnace.

The inventor asserts that a very large portion of the energy expended in combustion may be restored in electric energy without any complicated mechanism. Ordinary zinc piles are costly, and accumulators have to be frequently charged, while this new generator requires merely fuel and a little water. Mr. Kendall estimates that a ton of carbon used to heat the pile and the generator of hydrogen will give at least three times as much energy as a ton of fuel employed to drive a steam engine and dynamo. It is proposed to apply this new apparatus as a generator for actuating electric boats or for electric lighting.—*La Lumiere Electrique.*

ELECTRICITIES OF CONTRARY NAME DEVELOP IN EQUAL QUANTITIES.

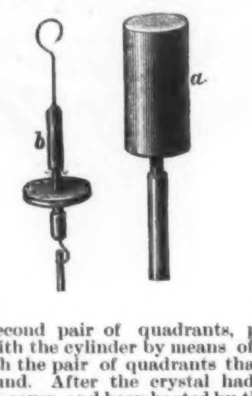
In Wiedemann's Annals, Mr. Dorn, of Darmstadt, describes some experiments undertaken to confirm the theoretic principle which is expressed in the caption to this note.

If we heat a crystal of tourmaline at one of its extremities and cause it to pass quickly through a flame, it will at first exhibit no trace of electricity; but, while it is cooling, we can often detect at its extremities a considerable quantity of electricity, which is sometimes of the same name. According to the principle above enunciated, electricities of contrary names ought to develop in equal quantity in the interior of the crystal or upon the lateral surface. If, in fact, after heating the tourmaline, we put it into a hollow and insulated body, an electrometer connected with this conductor will show no development of electricity during the cooling of the crystal.

In his experiments Mr. Dorn employed the following arrangement: A copper cylinder, *a*, 1½ inches in length and ¾ inch in diameter, was fixed to the extremity of a flat ebonite rod, and was provided with a cover, *b*, which could be raised by means of a strong insulated brass wire (see figure). The crystal was attached by means of a small brass hook connected with the cover, *b*, and insulated through the intermedium of a strip of ebonite.

One of the pairs of the electrometer quadrants was always grounded, while the other pair was insulated in such a way that it received no appreciable charges, either from the movable charged piece of the electrometer or from the ambient air, even after an insulation of long duration.

As a result of several experiments, the capacity of the pair of the insulated quadrants was found to be equal to that of the cylinder seven times. In these experiments, the second pair of quadrants, put in communication with the cylinder by means of a wire, was connected with the pair of quadrants that communicated with the ground. After the crystal had been lifted along with the cover, and been heated by the flame of a Bunsen burner, it was quickly put back into the cylinder, when, upon breaking the connection between the two pairs of quadrants, not the least deflection could ever be found, and yet the quantity of electricity developed was usually considerable, as has been stated above.

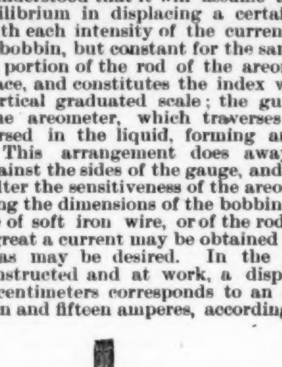


In one special case, the extremity of the crystal having been heated for 10 seconds in a small flame, and the crystal removed from the cylinder after the lapse of a minute, negative electricity was found at both extremities. When the duration of the heating was longer, and the crystal remained longer in the cylinder, positive electricity was detected at the upper extremity, and negative at the lower, and in so great a quantity that the luminous points several times exceeded the limits of the scale when the cover and crystal were lifted. This fact can be explained by the theory that a portion of the induced electricity upon the cylinder is removed with the cover.—*La Lumiere Electrique.*

ELECTRIC AREOMETER.

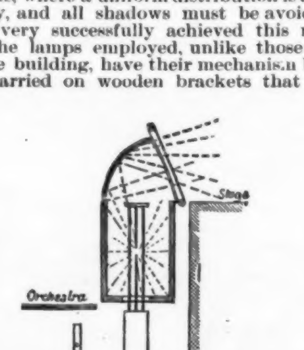
Apparatus for measuring electrical currents based on the employment of magnetic needles or permanent magnets are, as is well known, affected to a large degree as much by the variation of terrestrial magnetism as by the variation of the magnetic state of the magnets themselves. The indications furnished by instruments of this description which are provided with a fixed graduation in amperes or volts present guarantees only as far as their standard is verified at short intervals. This is a serious inconvenience, especially in industrial applications, for which these instruments possess the great advantage of giving immediate and continuous records. The new amperemeters and voltmeters do not contain a permanent magnet in their construction, and are consequently free from the errors just mentioned. They are based upon the action exerted by a solenoid upon a bundle of soft iron wire, movable in its interior and maintained by an antagonistic force. They resemble the electro-magnetic balance of M. Becquerel, and allow, like that instrument, the action of the electric current to be weighted, so to say. In order to obtain this result, the apparatus we illustrate herewith—which might be called an electric areometer—is simply formed of a bundle of soft iron wire placed inside a metallic areometer, plunged into a gauge filled with water, and surrounded by a bobbin which is traversed by the current to be measured. The initial position of the areometer—regulated by the level, maintained constant, of the liquid—being always the same, it will be understood that it will assume a position of fixed equilibrium in displacing a certain quantity, varying with each intensity of the current which traverses the bobbin, but constant for the same intensity. The upper portion of the rod of the areometer has a plane surface, and constitutes the index which moves along a vertical graduated scale; the guiding of the rod of the areometer, which traverses a metallic eye immersed in the liquid, forming an important feature. This arrangement does away with the friction against the sides of the gauge, and does not in the least alter the sensitiveness of the areometer.

In varying the dimensions of the bobbin and those of the bundle of soft iron wire, or of the rod of the areometer, as great a current may be obtained for a given intensity as may be desired. In the instruments already constructed and at work, a displacement of about ten centimeters corresponds to an intensity of between ten and fifteen amperes, according to the apparatus, or a potential difference of one hundred volts. The bobbins of the amperemeters are formed of one or two layers only of very thick wire; they possess a resistance of between 0·01 and 0·02 ohm only. The apparatus may, therefore, be introduced without inconvenience into most electrical circuits. The bobbin of the voltmeter is of fine wire, and offers a resistance of about 1,700 ohms. The curves representing the displacement of the areometer as a function of the intensity or of the electromotive force of the currents offer a point of inflection which does not depart far from a straight line. The variations have been determined by utilizing this part of the curve. The apparatus can be modified in accordance with the object proposed. The areometer and the solenoid could be brought back to a position relatively constant by charging the areometer or by displacing the bobbin. In this case the law of action is more simple, and the graduation of the instrument would be sensibly reduced to a single coefficient, in place of the determination of a curve. The apparatus is not sensibly affected by variations of temperature, nor are its indications altered by the proximity of metallic substances or even by very powerful magnets, although its sensitiveness is very great. It is expected that the advantages possessed by this instrument will render it very serviceable to electricians.—*Iron.*



ELECTRIC LIGHTING OF A THEATER.

The Eldorado Theater, or concert *cafe*, in Paris, is now lighted by thirty-seven Cance electric lamps. A description of this installation, given in *Engineering*, contains the accompanying illustration and statement relative to the arrangement of the foot lights: "Another interesting portion of the installation is that of the footlights, where a uniform distribution is absolutely necessary, and all shadows must be avoided. M. Cance has very successfully achieved this result as follows: The lamps employed, unlike those used for lighting the building, have their mechanism beneath. They are carried on wooden brackets that slide on vertical posts, and can be fixed at any desired height by means of keys. The upper part of the lamp is surrounded by a wooden trough, extending the whole length of the stage, and lined with sheet metal, painted white and flatted. The trough is surmounted by a curved silver-plated hood, as shown in the sketch. In front of the trough and the reflector the space is filled with glass that protects the lamps. To produce gradual effects of darkness without touching the lamps a blind running on suitable rollers can be drawn over the glass, the density of this blind being graduated so as to cut off more or less light as may be desired, or to produce special colored effects."



COMPARATIVE RESULTS OF OPERATIONS IN BELLEVUE HOSPITAL, NEW YORK.

By STEPHEN SMITH, M.D., New York.

FORMERLY everything was subordinated to celerity in operation; now mere haste is mentioned but to be condemned; recovery without suppuration is the end sought; perfect cleanliness and thorough antisepsis of operation, assistants, patient, instruments, and dressings is required, by the use of (1) soap and water to external parts, (2) carbolic solution for all instruments, (3) bichloride solution for all surfaces and tissues, and (4) iodoform for external dressings—all this in contrast with the disregard for cleanliness formerly in vogue. Sponges are elaborately purified; the ligature is aseptic and not expected to "come away," drainage tubes used but as a temporary expedient, if at all, no suppuration being expected, and the lips of a wound being brought by deep and superficial sutures into complete apposition; in contrast with former careless methods of applying dressings the present method is careful in the extreme, consisting of a dusting with iodoform, layers of disinfected material with iodoform between the layers, the whole being retained by bandages of disinfected materials carefully preserved in a disinfected atmosphere. The results obtained are as much in contrast as are the procedures: Compound fractures, which under the old fracture-box or gypsum-splint treatment always suppurated, resulting often in loss of life or limb, are almost uniformly cured without any drawback by (1) removing from the wound every particle of matter liable to injure the tissues and induce suppuration; (2) placing in fixed apposition all the tissues composing the wound; (3) cleansing and disinfecting the wound, and protecting it from becoming soiled during recovery; (4) protecting the wound by immovable dressings from any movement of the parts entering into it while the process of repair is going on. Amputations, the wounds from which rarely, if ever, recovered, except after long continued suppuration, the larger ones being terribly fatal, are now among the most successful operations. Excision of the larger joints, which was formerly a most doubtful and dangerous operation, involving suppuration and confinement for months, as a rule now do not suppurate, union taking place by rapid and healthy granulation.

The danger of secondary hemorrhage after the ligature of large arteries has passed away now that the artery need no longer be divided by the ligature, but is strengthened by a non-irritating and preferably absorbable ligature; no suppuration occurring, the artery enlarges externally at the seat of the operation, while the coagulum organizes internally, and closes its caliber. Cold abscesses, not connected with bone, were preferably allowed to open themselves, or, if touched at all, opened by a "valvular" incision and the pus allowed to flow out at several sittings; now they are cured promptly, without suppuration, by opening freely and, with the curette, scraping out all old granulations and diseased tissues, cleansing the cavity with bichloride solutions, and pressing the walls together with disinfected dressings. Abscesses connected with bone are freely opened and thoroughly cleansed with bichloride solutions, which secures rapid recovery. Fractures of the patella, formerly the surgeon's *bete noir*, are invariably cured by wiring the fragments, with antiseptic precautions. The same change is observable in the gynecological surgery of the institution. All these improvements are secured in spite of the fact that the hospital is an old shell, containing in its walls and its environments all the conditions that in modern times are regarded as unhealthful and unsanitary, and can be attributed only to the superiority of the methods now employed over those formerly in vogue.—*Annals of Surgery.*

REMOVAL OF SEWAGE.

AT a recent meeting of the American Society of Civil Engineers, New York, a paper by Mr. W. Howard White, M. Am. Soc. C. E., on European Sewage and Garbage Removal, was read. This paper states that:

For sewage removal in Europe, five methods are at present in use: 1st. Dry removal. 2d. Water carriage, simple. 3d. Water carriage, with purifying (precipitation) works. 4th. Water carriage, with filtration or irrigation. 5th. Dry removal, and working up into salable products. The first method is in most general use still. The second method, more or less introduced into all large cities, was brought about by covering in of water-courses and introduction of pressure water supply. Denser population and sluggish rivers led to use of third method, leading, first, to intercepting sewers, and then to purification. The latter is about to be adopted in London (recommended by Royal Commission, 1884, who declare condition of Thames below London unbearable). Experiments show that a month's sewage of the city is generally to be found floating between Barking and the river mouth.

Precipitation is successfully practiced in Leeds and other cities, giving a clear effluent and a disposable, but non-salable, manure. It is claimed that the effluent again decomposes, if carried far in sluggish streams.

Cost per capita in Leeds for purification, 22 cents per annum.

Cost per capita in Leeds for dry removal, 24 cents per annum.

If the whole population in sewered district which now uses sewers for slops used them also for excreta, cost per capita is estimated at 16 cents. This includes cost of purifying slops. Dry removal figure (24 cents) includes removal of ashes and garbage.

No allowance is made for cost and maintenance of sewers, because these are needed any way for slops and storm water.

Taking interest and cost of maintenance on these into account, total cost per capita per annum for storm water, sewage, and slops, 45 cents.

Knostrop works at Leeds consist of 12 settling basins, 60 feet by 100 feet, with pumps to raise sewage, and appliances for cutting out any basin for cleaning. Precipitation effected by mixing milk of lime with sewage. Sewage passes from tank to tank, over division walls, and under intercepting walls, to prevent surface current. First five tanks cleaned every five days; sixth and seventh, about once a week. Others very rarely. Deposit in tanks, when cleaned, averages: In No. 1, 21 inches deep; No. 2, 18 inches; No. 3, 10 inches; No. 4, 6 inches; No. 5, 5 inches; No. 6, 4 inches. In the last five, never over 1 inch. In the works now building at Frankfort-on-the-Main, sewage flows through 3 tanks used simultaneously, giving slower velocity, which if attained may be advantageous; but no precautions are taken against surface flow. Out of four tanks provided, one will always be in process of cleaning. By placing works some distance below the city, Mr. Lindley has been able to operate ordinarily without pumping, except for cleaning basins. He has thought it necessary to cover the basins with vaults, to prevent interference with cleaning by ice. This does not seem necessary.

Precipitant to be used at Frankfort is alumino-ferric. Acid in this is set free by reaction with alkalies in the sewage, and alumina remaining precipitates the solids by its affinity for organic substances. As alkalies in sewage are not sufficient to neutralize all the acid, milk of lime is added to render the whole action of alumina available. Where there is much acid in sewage, this process is not practicable, because as much lime is needed as without the process.

Advantages claimed: 1st. Precipitation of impurities in solution as well as in suspension. 2d. Effluent not so liable to after putrefaction. 3d. Does not make so much sludge. 4th. Less danger of escape of free lime.

Irrigation is used, with great advantage, for smaller towns.

Best conditions: Town lying high enough for natural drainage to irrigation farm, and latter high enough to be drained by 5 foot subsoil drains; depth of drains determined by climate partly. Town of Harrogate, Yorkshire, is a good example of irrigation. Has the above conditions, with slopes steep enough to give rapid circulation and rapid drainage. Population, 10,000. Sewage farm, 230 acres. Depth of drains, 4 feet (found too shallow). Effluent fairly good, except occasionally, in dry weather, when ground cracks. In our drier climate, with land equally sloping ($\frac{1}{14}$ to $\frac{1}{16}$), drains should not be less than 5 to 7 feet; with flatter land, shallower drains can be used, but more land is needed.

Sewage arrives at sewage farm finely comminuted. Leaves no paper on surface of farm. When sewer was broken near town, ground in neighborhood was covered with paper. Authorities believe paper is ground up and dissolved in flowing half mile further to sewage farm. Appears more probable that it collects at points in the system, and that the flood that broke the sewer (storm water being partly carried in it) dislodged it.

Harrogate's experience shows the difficulty of using irrigation for cities over 100,000. Sewage farm becomes too large, requiring 1 acre for 50 to 100 people with favorable Harrogate conditions, while for large cities the farms would have to be scattered about. Harrogate's farm, worked by city and fairly remunerative, could be combined with poor farm in our towns of similar size.

Favorable features in our climate: The ameliorating effect on ground of warmth of sewage in winter, and greater capacity for sewage in our dry summers.

Modification of irrigation is filtration proposed by Frankland in 1870. Land is chosen of a level character, with sandy or chalky soil, and thoroughly sub-drained. Divided into 4 plats, upon which sewage stands successively 6 hours on each. Accepted minimum area, 1 acre per 1,000 people. Town of Kendal, Westmoreland, has purified sewage this way for ten years, with 850 people per acre, and effluent still good. Only coarse crops can be raised, and it seems only a question of limited time until soil becomes choked with sludge. Recommended for large places only, with preliminary precipitation, as by Royal Commission on Metropolitan Sewage Discharge (London) in 1884. Precipitation works proposed at Barking, discharging over filtration area and again into Thames. Cost of preparation of land for this plan, \$350 per acre. Land itself for London would cost \$1,000 per acre. Cost per capita for filtration would be 5 cents. Precipitation, as in Leeds, 16 cents. Total, 21 cents per annum. Sewer for London can be extended to deep water of British Channel at annual cost per capita for construction, maintenance, and pumping out, 27 cents for population of 6,000,000. Cost of above outlet would cover one with slight addition for the population of the Thames Valley of 10,000,000. Cost per head would then be 20 cents against, at least, 21 cents, as before, for filtration requiring 10,000 acres for filter-beds alone.

Recent experiments show advantage to fish culture of very dilute sewage, forming an argument for discharge of sewage into large bodies of water.

5th. Method practiced on largest scale, at Manchester, England, where urine and fæces partially deodorized with the house ashes are removed in pails to manufacturing depot, where they are converted into manure (along with the market garbage and dead animals) and into a variety of materials like soap, oil, candles, and mortar, all of which are used by the corporation, except mortar and manure, which find ready sale. Cost uncertain, somewhere between 24 cents and 37 cents per capita per annum. This includes also destruction of garbage and dead animals, which expense I have not been able to separate.

Liernur separate pneumatic system costs, at its best, 22 cents per head per annum, exclusive of interest on plant and dust and garbage collection. More expensive than any other well-arranged system.

Summing up: Dry carriage never economical or healthful. Combined wet carriage expedient for closely built towns or quarters of same where slopes are not excessive. This supposes branches large enough to carry sewage and relieve streets of ordinary rains, and provision of overflows for intercepters to carry off all water not needed to dilute sewage to innocuous points.

Separate system, applicable to steep streets or permanently rural neighborhoods, where storm water can be carried in gutters and natural water-courses.

As to disposal of sewage: The sea or a body of fresh water as large as our great lakes is a natural receptacle. To be discharged in small towns on such waters directly into the same, with provision for future interception and carriage away from town or out into the sea or lake to a safe distance. Where direct discharge is inadmissible, irrigation first resort, followed by precipitation and filtration.

Berlin, instance of large city using irrigation. Had in 1884 13,322 acres of sewage farms, with 1,200,000 population, and will probably be driven eventually to preliminary precipitation. Impossible to lay down hard and fast rules. Dantzig irrigates, though near the Baltic, because it was able to do so to great advantage. Providence declined to irrigate, because it could purify sufficiently by precipitation to discharge into Narragansett Bay.

New York will probably have to carry its sewage to sea eventually, and Chicago several miles out into the lake, at a point a good way from its water-taking inlet.

Cities on the Mississippi will, at a distant day, have to resort to preliminary purification before discharging into the river.

European sewerage depends too much on hand cleaning. Sewers should clean themselves by normal flow, aided by drains or automatic flushing with ground or other water.

No particles should enter a sewer which the minimum velocity in the same cannot carry. The main difficulty, where sewers are at all well proportioned, is with street washings. These should be kept out by proportioning catch-basins so as to drop all heavy matters into the bottom, by making the velocity through the basin at all times less than the least velocity ever occurring in the sewer, and intercepting floating matters by a diaphragm across the basin. The diaphragm to be removable, and bottom of basin to be formed by a pot, which could be lifted and dumped by a derrick on a wagon for the purpose of carrying off the washings. Grease should always be shut out of the sewers by grease traps at the houses.

That fouling matters of a heavy or floating nature (not suspended) can be kept out of sewers is shown by the Dantzig experience with siphons under the river, which have required no cleaning for fourteen years, owing to the adoption of measures similar to the above. Overflows for storm water had better be long, narrow openings at the level in the sewer to which it is filled when enough diluted to overflow, allowing swimming matters to pass over as soon as this level is exceeded. Should be on the side of the sewer and not on its axis, so that the current would scour them, and not tend to choke them.*

Sewers large enough to enter can be made at small expense large enough to carry all underground pipes and electric wires, and give room for making repairs and connections without tearing up the streets.

Ventilation in European systems wrong in using house soil-pipes for ventilating sewers. American systems would be better if only one untrapped opening to open air were used, viz., a pipe carried up along kitchen chimney. This would cause constant tendency of air in house drainage toward this pipe in case any leak occurred in the pipes—the air drawing into the pipes from house, and up kitchen-chimney pipe—and would avoid freezing of water-pipes by circulation of cold air in soil pipes alongside them. Only chance of sewer gas getting into house with such arrangement is stoppage of the kitchen-chimney air-pipe at a time when house traps were empty, or by kitchen chimney being cold under same circumstances, which almost never occurs, if ever, in an occupied house.

Disposal of dead animals, garbage, dust, ashes, and other matters not suitable for the sewers, handled in the United States very crudely.

Destructors applied at various points in England and Holland accomplish this by fire at small cost. The two at Leeds consist of brickwork cells, with sloping hearth continued down into grates. All refuse is fed in at top, and works down gradually to the grate, where fire once started is kept up by the refuse. The hot gases pass off by side openings through the flues of a steam boiler, which runs a mortar-mill. Latter grinds up clinker from the furnaces with lime, and makes first-class mortar. Old iron is sold as it comes out of ash-pit. All infected mattresses and clothing, and dead animals and condemned meat, are put into the destructor and consumed, without any fuel being used except the dry garbage and cinder left in the ashes from the houses.

Burmantoft destructor burnt up in year ending August 31, 1884, 1,538 tons rubbish, 23,207 tons ash-pit rubbish, 45 beds, 96 mattresses, 58 pigs, 9 cows, 9 sheep, 4 quarters bad meat, the product of 100,000 people, at a net cost of £1,087 12s. 10d.

If the system were applied to New York, with a population of 1,500,000, where removal of same matter to deep water now costs \$175,000 to \$200,000 annually, the Leeds cost per 1,000 of \$50 per annum would make \$75,000 for New York. Destructors are placed in Leeds on less valuable property; rate of interest is about three-quarters of that here; cost of labor, two-thirds. Safe to estimate expense at double that of Leeds, or \$150,000 for New York, leaving still a margin, after absolutely destroying many things now only partially got rid of. It is alleged that the poorer population wash their ashes into sewers and burn the large cinder. Hence, not enough fuel collected from ash-bins to operate destructors. If so, the practice should be stopped by inspection, and by obliging tenement owners to provide ash-spouts over which ashes could be sifted.

ON A CHEMICAL DIFFERENCE BETWEEN LIVING AND DEAD PROTOPLASM.†

By OSCAR LOEW, Ph.D.

IT has been long since a question why the manifold chemical changes going on in a living cell of a plant or an animal suddenly cease with the death of the cell. None of the hypotheses offered proved to be satisfactory. The living cell is undoubtedly full of a wonderful chemical energy, and the most complicated syntheses are performed with ease. Think of a bacterium, that lives and multiplies in acetate of ammonia solution, and forms its albumen, fat, and cellulose from this compound of so simple a composition! Think of the continued production of protoplasm that goes hand in hand with the perpetual destruction by respiration, and certainly a most energetic chemical activity becomes evident.

* Leeds borough engineer has devised overflow by letting off the surplus water under a float gate, which rises at the point of proper dilution of sewage, and at same time shuts gate in main sewer, so that all the flow is eventually discharged through overflow as long as the flood continues. Makes it possible to proportion intercepters for sewage alone. Some doubt how satisfactorily such a float-gate would work without very careful inspection.

† Lecture before the Physiological Section of the British Association meeting in Aberdeen, September, 1885.

In 1875 the first attempt was made to trace this energy back to a peculiar chemical constitution of the albumen that composes the protoplasm. The physiologist E. Pflüger, in Bonn, was the author of this hypothesis. He believed the albumen to contain cyanogen groups, which take up the elements of water, and thus the albumen would lose the agility of the atoms and change into another substance of less chemical energy—the dead albumen.

This hypothesis hardly found the recognition it deserved. It was only Detmer, Professor of Botany in Jena, who in 1880 accepted and defended similar views. In his opinion the chemical change of the albumen takes place by atomic displacement; and while in the living albumen a most energetic motion of the atoms leads to a continual dissociation, this ceases entirely in the dead or ordinary albumen. Neither Detmer nor Pflüger made any experiments whatever.

It was in 1881 when, starting from my own hypothesis of the formation of albumen in plants, I was led to the conclusion that the albumen of the living protoplasm contains aldehyd groups which are lost in the albumen of the dead protoplasm by atomic displacement. I therefore concluded that these easily changeable and energetic aldehyd groups could be demonstrated by the action upon an alkaline silver solution. Living cells should give a reduction of the silver solution, dead cells should not. The first experiment succeeded. It was made with an alga named Spirogyra. You see here the slides, which under the microscope demonstrate this difference very clearly; the protoplasm is perfectly black in one case, and not at all in the other case, where dead cells (killed by a temperature of 50° or by an acid) had been submitted to the silver reagent. This silver reagent shows still action in a dilution of 1 part of silver to 200,000 parts of water. Not all objects show this reaction. Objects in which the killing process is performed too quickly cannot give the reaction, the silver solution itself being poisonous. There can also exist many obstacles that prevent the reaction, as presence of chloride of sodium, existence of an impenetrable membrane, etc. The phenomenon known as argyria is probably also founded upon the reaction of the active albumen of living protoplasm. In this case the metallic silver is deposited in different organs of the human body, when treated internally by nitrate of silver.

The kidneys of frogs and caterpillars show also the reaction, young hairs of plants, parts of leaves, roots, and the cells in living wood. Diatoms and infusoria die altogether too quickly to give the reaction; also some algæ of the higher classes behave likewise, and parts of most of the animals.

Many experiments were made to prove that this reaction is caused solely by the character of the *albumen* of the living protoplasm. It will suffice here to mention that I have *shown by analysis* that the oxygen of the reduced silver oxide has really entered into the molecule of the albumen.

The supposition that the reducing atomic groups in the active albumen are nothing but aldehyd groups receives a strong support by the fact that *hydroxylamine* proves to be a poison of the most general character. We know that this substance acts upon all aldehyds with great readiness, even in a very diluted and perfectly neutral solution. Its poisonous qualities can find no other explanation than that it acts upon the aldehyd groups in the living protoplasm, causing disturbances that lead to disorganization in the cells.

While these experiments prove that the albumen of the living cell is quite a different substance from that of a dead cell, and thus a foundation for an explanation of the great chemical activity of the living cell is furnished, still I am at the same time far from believing that hereby all vital action can be explained. The cause for the divisions of cells, the nervous activity, the growth after prescribed rules, the wonderful differentiation of the various functions of a living body, the mechanical actions, the construction itself of the protoplasm, that appears as a wonderful machinery built up with molecules of active albumen—all this appears as mysterious as heretofore.

[For details see "Die Chemische Kraftquelle im Lebenden Protoplasma," I. A. Finsterlin. Munich, 1882.]

AGATIZED AND JASPERIZED WOOD OF ARIZONA.

By GEORGE F. KUNZ.

UNDOUBTEDLY one of the greatest of American wonders is the silicified forest in Arizona, known as Chalcedony Park—a park only in name, however, for the giant trees which once grew there have long since fallen and silicified into agate and jasper. It is situated eight miles south of Corriza, a station on the Atlantic and Pacific Railroad, in Apache County, Arizona, twenty-four miles southeast of Holbrook. This marvelous deposit of probably a million tons of silicified trees covers a thousand acres. The wood is generally found projecting from the volcanic ash and lava, which is covered with sandstone to the depth of from twenty to thirty feet, and lies exposed in the gulches and basins where the water has worn away the sandstone.

The silicification probably took place in the following manner: The trees were overthrown and covered with volcanic ashes and tufa; the heated silicified waters, either gushing from springs or forced up by the violent volcanic action which felled the trees, percolated through the ashes, cooled on reaching the tree-level, and thus produced conditions favorable to silicification.

The moisture in the tufa may have effected a partial alteration, as also any waters that may have filtrated through it from rains or springs, either hot or cold. Under these circumstances decomposition would be assisted, and much silica be set free. The waters would become charged with this, the silica being held partly in solution similar to that in liquid glass, the silicate of soda of commerce. The silicious water then slowly penetrated the wood buried in the tufa, and was slowly deposited in the cells of the wood. In this manner the fibers of the wood were replaced by the silica. The process was evidently a slow one, and the trees, from all appearances, were partly decayed and water-logged when the silicification took place. The jasper and agate generally replaced the cell-walls and fibers, and the transparent quartz filled the cells and interstices, especially where the structure was broken down by decay. These cell-centers and cavities produced the conditions favorable not only for the deposition of the silica as quartz, but also for the formation of the drusy, crystalline cavities of quartz and amethyst that enhance the beauty of the material so much. It is evident, from the rich variety of colors, that the waters held oxides of iron and perhaps manganese, as well as silica, the red color being caused by hematite, the yellows and browns by limonite, and the black by oxides of manganese.

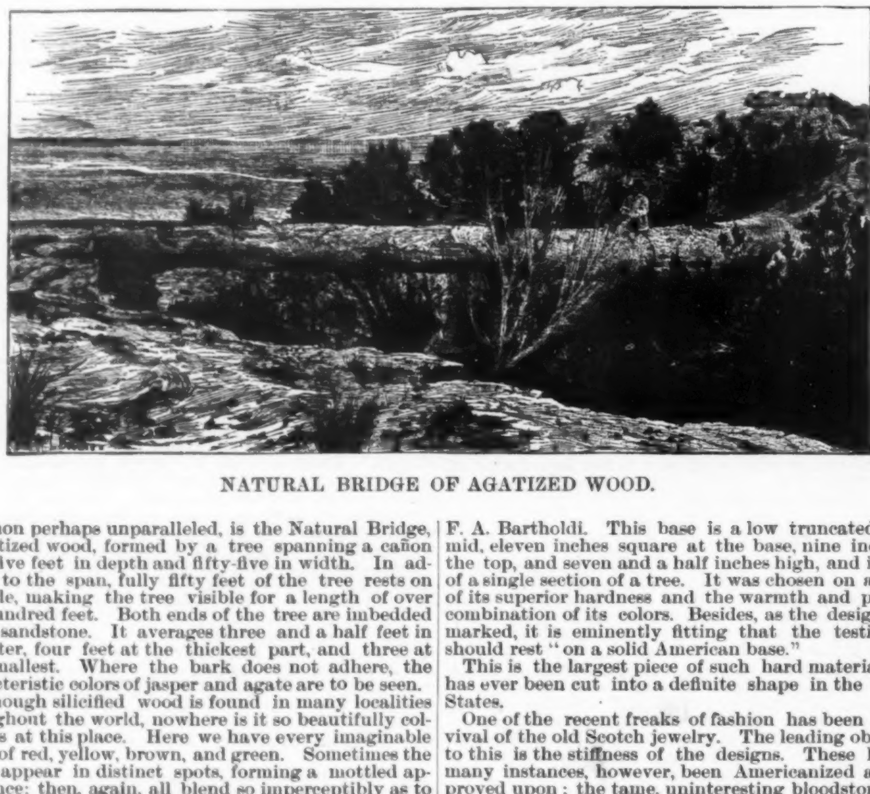
It is possible also that the ash was deposited partly in water, and thus heated it. There is every indication that the deposit is of considerable depth. Over the entire area the trees lie scattered in all conceivable positions and in fragments of all sizes, sometimes resembling a pile of cart-wheels. A tree one hundred and fifty feet in length is often found broken up into as many sections of almost uniform length, presenting the appearance of having been sawed asunder for shingle-blocks by some prehistoric forester.

Again we find a giant tree broken into countless fragments, ranging in size from a small pebble to a fair sized bowlder. Perfect-shaped cubes, ready to be polished and used for paper-weights, are also found. These multiplied fractures are the result of alternate heat and cold acting on the water collected in the fissures of the tree.

The highest point in the park is some two hundred feet above the surrounding level, and it is here that the buried trees can be seen to the best advantage. Some of them are one hundred and fifty feet long and ten feet in diameter, and lie exposed in all conceivable positions. One section of a tree, which has been broken up, measures eight feet in diameter, ten feet in length, and weighs several tons. The tree was originally about two hundred feet long. Some pieces of the trunks of these trees, which were brought to New York, ranged from eight inches to three feet in diameter, and from twenty-five to one thousand pounds in weight. The perfect preservation of these trunks is remarkable. The rings are so distinctly visible as to convince even the most incredulous of their organic origin.

The most interesting points in the park have been suggestively named the Agate or Natural Bridge, Agate Gulch, Amethyst Point, Fort Jasper, etc.

The most remarkable feature of the park, and a phenomenon perhaps unparalleled, is the Natural Bridge, of agatized wood, formed by a tree spanning a cañon forty-five feet in depth and fifty-five in width. In addition to the span, fully fifty feet of the tree rests on one side, making the tree visible for a length of over one hundred feet. Both ends of the tree are imbedded in the sandstone. It averages three and a half feet in diameter, four feet at the thickest part, and three at the smallest. Where the bark does not adhere, the characteristic colors of jasper and agate are to be seen.



NATURAL BRIDGE OF AGATIZED WOOD.

Although silicified wood is found in many localities throughout the world, nowhere is it so beautifully colored as at this place. Here we have every imaginable shade of red, yellow, brown, and green. Sometimes the colors appear in distinct spots, forming a mottled appearance; then, again, all blend so imperceptibly as to make a much more pleasing and harmonious effect than the decided banding of the agate, where the lines of demarkation between the colors are so distinct as to become obtrusive. The colors above mentioned are often relieved by white, black, and gray, and by transparent spaces of brilliant quartz-crystals, or—as sometimes occurs—of amethyst.

Broken sections of the hollow trunks are often lined with amethyst, quartz, and calcite, which add their brilliancy to the endless variety of color.

Beautiful as the wood is to the naked eye, a microscope is needed to reveal its true beauty. Not only does the glass enhance the colors, but it also renders visible the structure, which has been perfectly preserved, even to the forms of the minute cells, and is more beautiful now than before the transformation.

Dr. P. H. Dudley, of New York, microscopically examined some sections of this wood, and finds that part of it at least belongs to the genus *Araucaria*. He says that the *Araucaria excelsa*, the Norfolk Island pine of the South Pacific Ocean, grows to a height of from one hundred and fifty to two hundred feet. In radical longitudinal section, the lenticular markings on the wood-cells near each end are in double rows and contiguous, the markings of one row alternating with those of the other, giving the appearance of the beautiful hexagonal markings of this genus. In central portions of the cells sometimes only one row of markings is seen, and some cells show only one row. Medullary rays were indistinct.

Other portions resembled our red cedar (*Juniperus Virginianus*) when grown in the extreme South. The cell-structure of some indicates a growth in a mild and uniform climate, the annular rings being marked only by one, two, three, or more slightly smaller hexagonal or rounded cells, not tabular, as is usually the case. The cell-walls were nearly uniform in thickness. All the specimens examined showed that the wood originally was undergoing decay before being filled with the various media which afterward solidified. On some of the specimens traces of fungi (*mycelium*), causing decay, were discovered. The beauty of the wood is largely due to the destructive influence of fungi.

Agate-cutting has been carried on as an industry for over three hundred years in the Oberstein district, in Germany, but little attention has been paid heretofore to the cutting of large masses, because few agates are found over a foot in diameter, and the banding is not such as to offer much inducement. But in the future this material will doubtless be in great demand for interior house decoration, where it can be advantageously used as inlays in wood or stone; for paneling and wainscoting walls; for tiling; and, if desired, for entire floors. Whole table-tops could be made of the largest size from a single section of one of these giant trees, and the design would be nature's own incomparable handiwork. For mosaic-work it would also find a ready use, since the infinite diversity of color would afford an ample field for the imagination of the skillful artisans employed at this industry.

The rich, warm, blending colors, and the remarkable polish that this material is susceptible of, are the main features that will always give it a high place among minerals of its class. In fact, it is a question whether any of the ornamental stones, such as jade, jasper, agate, or even the marbles, have the two desired qualities to such a degree.

As before stated, the deposit has been estimated at a million tons, but probably not more than a thousand tons would be suitable for the purpose of art, while for finer work only a small part of this would be available. One instance should be noted to show the high estimation in which this wood is held by foreigners. A Russian dealer recently paid five hundred dollars for a piece twenty-eight inches in diameter and thirty inches in length, to be cut into table-tops. A large lot was recently sent abroad for cutting, and we shall soon have a new decorative stone which will possess what very few now in use do—the proper hardness.

A piece of this material was selected by Mr. Joseph Pulitzer to form the base for the beautiful silver center piece which is being made by Messrs. Tiffany & Co., to be given as a testimonial to the eminent sculptor, F. A. Bartholdi. This base is a low truncated pyramid, eleven inches square at the base, nine inches at the top, and seven and a half inches high, and is made of a single section of a tree. It was chosen on account of its superior hardness and the warmth and pleasing combination of its colors. Besides, as the designer remarked, it is eminently fitting that the testimonial should rest "on a solid American base."

This is the largest piece of such hard material that has ever been cut into a definite shape in the United States.

One of the recent freaks of fashion has been the revival of the old Scotch jewelry. The leading objection to this is the stiffness of the designs. These have in many instances, however, been Americanized and improved upon; the tame, uninteresting bloodstones and agates giving place to our own richer and brighter stones and silicified woods.—*Popular Science Monthly.*

THE DOGS OF LONDON.

THE captured ownerless dogs are usually sent to an excellent institution, the "Temporary Home for Lost and Starving Dogs," in Battersea road, South Lambeth, the twenty-fourth annual report of which has been issued. The patrons are their Royal Highnesses the Prince of Wales and the Duke of Cambridge; the Earl of Onslow is the president, and the list of vice-presidents and of the council and managing committee includes many persons of distinction. Mr. J. C. Colam is the resident secretary, and Mr. A. J. Sewell is the (honorary) inspecting veterinary surgeon. This is, at present, the only place in London where lost dogs are received and properly cared for; and all, except a hundred or so in the year, are brought in by the police. In the twelvemonth preceding the date of last year's report, 14,772 dogs were received; and from Jan. 1 to Dec. 14 last year, 21,614. The recent police order, from Dec. 10, tended very greatly to increase the number captured, and the following figures show the increasing daily return for one week—Dec. 7, 304; 8, 253; 9, 242; 10, 266; 11, 353; 12, 412; and 14, 468. With regard to the detection of madness in the animals, it is scarcely possible for one, however slightly affected, to escape notice. There are seven keepers, all experienced men in discovering diseases, and a daily visit is made by Mr. Sewell, the veterinary surgeon. There are many kennels set apart for lame or diseased dogs, and several wired from top to bottom for the use of supposed "mad" animals. Of true rabies, there were thirteen cases detected in the Home in 1883, fifteen in 1884, and fifty-six cases were clearly developed in the kennels last year. The danger has been checked for the moment, but that the disease has been wholly eradicated is very doubtful. By the dogs being now taken to the Home,

a very large diminution in the number of stray and ownerless animals will be effected. Those wearing collars are kept five days, and those without collars three days, for their owners to come and claim them; after which time, if in good condition, they may be sold and delivered to respectable purchasers. Those which are in such a diseased and miserable state as to be unfit to live are put to a painless death, a number of them at once, by inhaling a narcotic vapor in the "lethal chamber," invented by Dr. B. W. Richardson. This "anæsthetic" mode of execution is similar in effect to the extinction of life by chloroform, and may be called "death by sleep." The apparatus is shown in one of our illustrations. A wooden chamber, having an internal capacity of 200 cubic feet, is closed at all parts, except the front sliding-door and the escape-pipe or flue occasionally used for the discharge of gas. It contains two boxes, 18 in. long and 4 in. wide, filled with Verity's patent gas fuel, a porous burnt loam, which absorbs the fluid poured in through a funnel at the top, and gives it out in volumes of vapor, when a current of charcoal gas, warmed by the stoves outside, is passed over the substance in the boxes. The fluid which produces the narcotic effect is a mixture of chloroform and bisulphide of carbon. The dogs condemned to this easy way of dying are placed in a cage of wooden framework, with an upper and lower division, which runs on wheels, over iron rails, through the sliding door into the "lethal chamber." The supply of narcotic vapor is duly regulated by the attendants, and in three or four minutes, probably, the animals have ceased to breathe. This is ascertained by hearing through a sort of stethoscope at the top of the chamber. It is believed that no sense of suffering is felt, the dogs becoming unconscious as soon as the sliding door is closed.—*Illustrated London News.*

SKETCHES AT THE DOGS' HOME, BATTERSEA, LONDON.

ADDRESS OF PROFESSOR T. H. HUXLEY ON RESIGNING THE PRESIDENCY OF THE ROYAL SOCIETY, NOVEMBER 30, 1885.

[Abstract.]

SUCH are the chief matters of business, if I may so call them, which it is proper for me, in my presidential capacity, to bring before the Society. But it has been not unusual, of late years, for the occupant of the chair to offer some observations of a wider bearing for the consideration of the Society; and I am the more tempted to trespass upon your patience for this purpose, as it is the last occasion on which I shall be able to use, or abuse, the president's privileges.

So far as my own observations, with respect to some parts of the field of natural knowledge, and common report, with respect to others, enable me to form an opinion, the past year exhibits no slackening in the accelerated speed with which the physical sciences have been growing, alike in extent and in depth, during several decades. We are now so accustomed to this "unhasting but unresting" march of physical investigation; it has become so much a part of the customary course of events, that, with every day, I might almost say with every hour, something should be added to our store of information respecting the constitution of nature, some new insight into the order of the cosmos should be gained, that you would probably listen with incredulity to any account of the year's work which could not be summed up in this commonplace of presidential addresses.

Nor shall I be chargeable with innovation if I add that there is no reason to suspect that the future will bring with it any retardation in the advance of science. The adverse influences which, in the middle ages, arrested the work commenced by the older Greek philosophers are so much weakened that they no longer offer any serious obstacle to the growth of natural knowledge; while they are powerless to prevent the extension of scientific methods of inquiry and the application of scientific conceptions to all the problems with which the human mind is confronted. If any prophecy is safe of fulfillment, it is that, in the twentieth century, the influence of these methods and conceptions will be incomparably greater than it is now; and that the interpenetration of science with the common affairs of life, which is so marked a feature of our time, will be immeasurably closer. For good or for evil, we have passed into a new epoch of human history—the age of science.

It may seem superfluous that I should adduce evidence in support of propositions which must have so much of the nature of truisms to you who are sharers in the work of science and daily witnesses of the effects of its productive energy. But the proverbial tendency of familiarity to be incompatible with due respect is noticeable even in our appreciation of the most important truths, and our strongest convictions need furbishing up now and then, if they are to retain their proper influence. I certainly cannot accuse myself of ever having consciously entertained a low estimate of the past work or the future progress of science; but, a few months ago, enforced leisure and the attainment of an age when retrospection tends to become a habit, not to say a foible, led me to look at the facts anew; and I must confess that the spectacle of the marvelous development of science, alike in theory and practice, within my own lifetime, appeared to me to justify a faith even more robust than mine in its future greatness.

For, if I do not greatly err, the greater part of the vast body of knowledge which constitutes the modern sciences of physics, chemistry, biology, and geology has been acquired, and the widest generalizations therefrom have been deduced, within the last sixty years; and, furthermore, the majority of those applications of scientific knowledge to practical ends, which have brought about the most striking differences between our present civilization and that of antiquity, have been made within that period of time.

To begin with the latter point—the practical achievements of science. The first railway for locomotives, which was constructed between Stockton and Darlington, was opened in September, 1825, so that I have the doubtful advantage of about four months' seniority over the ancestral representative of the vast reticulated fetching and carrying organism which now extends its meshes over the civilized world. I confess it fills me with astonishment to think that the time when no man could travel faster than horses could transport him, when our means of locomotion were no better than those of Achilles or of Ramses Maimun, lies within my memory. The electric telegraph, as a thing for practical use, is far my junior. So are arms of precision, unless the old rifle be regarded as such. Again, the application to hygiene, and to the medical and surgical treatment of men and animals, of our knowledge of the phenomena of parasitism, and the very discovery of the true order of these phenomena, is a long way within the compass of my personal knowledge.

It is unnecessary for me to enumerate more than these four of the many rich gifts made by science to mankind during the last sixty years. Arresting the survey here, I would ask if there is any corresponding period in previous history which can take credit for so many momentous applications of scientific knowledge to the wants of mankind? Depreciators of the value of natural knowledge are wont to speak somewhat scornfully of these and such-like benefactions as mere additions to material welfare. I must own to the weakness of believing that material welfare is highly desirable in itself, and I have yet to meet with the man who prefers material illfare. But even if this should be, as some may say, painful evidence of the materialistic tendencies incidental to scientific pursuits, it is surely possible, without much ingenuity, or any prejudice in favor of one or other view of the mutual relations of material and spiritual phenomena, to show that each of these four applications of science has exerted a prodigious influence on the moral, social, and political relations of mankind, and that such influence can only increase as time goes on.

If the senseless antipathies, born of isolation, which formerly converted neighbors, whether they belonged to adjacent families or to adjacent nations, into natural enemies, are dying away, improved means of communication deserve the chief credit of the change; if war becomes less frequent, it will be chiefly because its horrors are being intensified beyond bearing by the close interdependence and community of interest thus established between nations, no less than by the improvement of the means of destruction by scientific invention. Arms of precision have taken the mastery of the world out of the hands of brute force and given it into those of industry and intelligence. If railways and electric telegraphs have rendered it unnecessary that modern empires should fall to pieces by their own weight as ancient empires did, arms of precision have provided against the possibility of their being swept away by barbarous invasions. Health means not merely wealth, not merely bodily welfare, but intellectual and moral soundness; and I doubt if, since the time of the father of medicine, any discovery has contributed so much to the promotion of health and the cure of disease as that of the part played by fungoid parasites in the animal economy, and that of the means of checking them, even though, as yet, unfortunately it be only in a few cases.

But though these practical results of scientific work, during only two generations, are calculated to impress the imagination, the Fellows of this Society know well enough that they are of vastly less real importance than the additions which have been made to fact and theory and serviceable hypothesis in the region of pure science. But it is exactly in these respects that the record of the past half century is so exceptionally brilliant. It is sometimes said that our time is a day of small things—in science it has been a day of the greatest things, for within this time falls the establishment, on a safe basis, of the greatest of all the generalizations of science, the doctrines of the conservation of energy and of evolution.

As for work of less wide scope, I speak in the hearing of those who can correct me if I am wrong, when I say that the larger moiety of our present knowledge of light, heat, electricity, and magnetism has been acquired within the time to which I refer; and that our present chemistry has been in great part created, while the whole science has been remodeled from foundation to roof. It may be natural that progress should appear most striking to me among those sciences to which my own attention has been directed, but I do not think this will wholly account for the apparent advance "by leaps and bounds" of the biological sciences within my recollection. The cell theory was the latest novelty when I began to work with the microscope, and I have watched the building of the whole vast fabric of histology. I can say almost as much of embryology, since Von Baer's great work was published in 1828. Our knowledge of the morphology of the lower animals and plants, and a great deal of that of the higher forms, has very largely been obtained in my time; while physiology has been put upon a totally new foundation, and, as it were, reconstructed by the thorough application of the experimental method to the study of the phenomena of life, and by the accurate determination of the purely physical and chemical components of these phenomena. The exact nature of the processes of sexual and non-sexual reproduction has been brought to light. Our knowledge of geographical and geological distribution and of the extinct forms of life, has been increased a hundredfold. As for the progress of geological science, what more need be said than that the first volume of Lyell's "Principles" bears the date of 1830?

This brief enumeration of the salient achievements of science in the course of the last sixty years is sufficient not only to justify what I have said respecting their absolute value, but to show how much it excels, both in quantity and quality, the work produced in any corresponding period since the revival of science. It suggests, as I have said, that science is advancing and will continue to advance with accelerated velocity.

It seems to me, in fact, not only that this is so, but that there are obvious reasons why it must be so. In the first place, the interdependence of all the phenomena of nature is such that a seemingly unimportant discovery in one field of investigation may react in the most wonderful manner upon those which are most widely remote from it. The investments of science bear compound interest. Who could have imagined that a curious inquiry into the relations of electricity with magnetism would lead to the construction of the most delicate instruments for investigating the phenomena of heat; to means of measuring not only the smallest intervals of time, but the greatest depths of the ocean; to methods of exploring some of the most hidden secrets of life? What an enormous revolution would be made in biology, if physics or chemistry could supply the physiologist with a means of making out the molecular structure of living tissues comparable to that which the spectroscope affords to the inquirer into the nature of the heavenly bodies! At the present moment the constituents of our own bodies are more remote from our ken than those of Sirius, in this respect. In the next place, the vast practical importance of the applications of scientific knowledge has created a growing demand for technical education based upon science. If this is to be effective, it means the extension of scientific teaching to all classes of the community, and the encouragement and assistance of those who are fit for the work of scientific investigation to adopt that calling. Lastly, the attraction of the purely intellectual aspects of science and the rapid growth of a sense of the necessity of some knowledge of the phenomena of nature, and some discipline in scientific methods of inquiry, to every one who aspires to take part in, or even to understand, the tendencies of modern thought, have conferred a new status upon science in the seats of learning no less than in public estimation.

Once more reverting to reminiscence, the present state of scientific education surely presents a marvelous and a most satisfactory contrast to the time, well within my memory, when no systematic practical instruction in any branch of experimental or observational science, except anatomy, was to be had in this country; and when there was no such thing as a physical, chemical, biological, or geological laboratory open to the students of any university, or to the pupils of any school, in the three kingdoms. Nor was there any university which recognized science as a faculty, nor a school, public or private, in which scientific instruction was represented by much more than the occasional visit of a vagrant orrery.

At the present moment, any one who desires to obtain a thoroughly scientific training has a choice among a dozen institutions; and elementary scientific instruction is, so to speak, brought to the doors of the poorer classes. If the rich are debarred from like advantages, it is their own affair; but even the most careful public school education does not now wholly exclude the knowledge that there is such a thing as science from the mind of a young English gentleman. If science is not allowed a fair share of the children's bread, it is at any rate permitted to pick up the crumbs which fall from the time table, and that is a great deal more than I once hoped to see in my lifetime.

I have followed precedent in leading you to the point at which it might be fair, as it certainly would be customary, to end by congratulating you, as Fellows of the Royal Society, on the past progress and the future prospects of the work which, for two centuries, it has been the aim of the Society to forward. But it will perhaps be more profitable to consider that which remains to be done for the advancement of science than to "rest and be thankful" in the contemplation of that which has been done.

In all human affairs the irony of fate plays a part, and in the midst of our greatest satisfactions, "*surgit amari aliquid.*" I should have been disposed to account for the particular drop of bitterness to which I am about to refer, by the sexagenarian state of mind, were it not that I find the same complaint in the mouths of the young and vigorous. Of late years it has struck me, with constantly increasing force, that those who have toiled for the advancement of science are in a fair way of being overwhelmed by the realization of their wishes. We are in the case of Tarpeia, who opened the gates of the Roman citadel to the Sabines, and was crushed under the weight of the reward bestowed upon her. It has become impossible for any man to keep pace with the progress of the whole of any important branch of science. If he were to attempt to do so, his mental faculties would be crushed by the multitudes of journals and of voluminous monographs which a too fertile press casts upon him. This was not the case in my young days. A diligent reader might then keep fairly informed of all that was going on, without robbing himself of leisure for original work, and without demoralizing his faculties by the accumulation of unassimilated information. It looks as if the scientific, like other revolutions, meant to devour its own children; as if the growth of science tended to overwhelm its votaries; as if the man of science of the future were condemned to diminish into a narrower and narrower specialist, as time goes on.

I am happy to say that I do not think any such catastrophe a necessary consequence of the growth of science; but I do think it is a tendency to be feared, and an evil to be most carefully provided against. The man who works away at one corner of nature, shutting his eyes to all the rest, diminishes his chances of seeing what is to be seen in that corner; for, as I need hardly remind my present hearers, that which the investigator perceives depends much more on that which lies behind his sense-organs than on the object in front of them.

It appears to me that the only defense against this tendency to the degeneration of scientific workers lies in the organization and extension of scientific education, in such a manner as to secure breadth of culture without superficiality: and, on the other hand, depth and precision of knowledge without narrowness.

I think it is quite possible to meet these requirements. There is no reason, in the nature of things, why the student who is destined for a scientific career should not, in the first place, go through a course of instruction such as would insure him a real, that is to say a practical, acquaintance with the elements of each of the great divisions of mathematical and physical science; nor why this instruction in what (if I may borrow a phrase from medicine) I may call the institutes of science should not be followed up by more special instruction, covering the whole field of that particular division in which the student eventually proposes to become a specialist. I say not only that there is no reason why this should not be done, but, on the ground of practical experience, I venture to add that there is no difficulty in doing it. Some thirty years ago, my colleagues and I framed a scheme of instruction on the lines just indicated, for the students of the institution which has grown into what is now known as the Normal School of Science and Royal School of Mines. We have found no obstacles in the way of carrying the scheme into practice except such as arise, partly, from the limitations of time forced upon us from without; and, partly, from the extremely defective character of ordinary education. With respect to the first difficulty, we ought, in my judgment, to bestow at least four, or better five, years on the work which has, at present, to be got through in three. And, as regards the second difficulty, we are hampered not only by the ignorance of even the rudiments of physical science, on the part of the students who come to us from ordinary schools, and by their very poor mathematical acquirements, but by the miserable character of the so-called literary training which they have undergone.

Nothing would help the man of science of the future to rise to the level of his great enterprise more effectually than certains modifications, on the one hand, of primary and secondary school education, and, on the other, of the conditions which are attached by the universities to the attainment of their degrees and their rewards. As I ventured to remark some years ago, we want a most favored nation clause inserted in our treaty with educators. We have a right to claim that science shall be put upon the same footing as any other great subject of instruction, that it shall have an equal share in the schools, an equal share in the recognized qualification for degrees, and in university honors and rewards. It must be recognized that science, as intellectual discipline, is at least as valuable, and, as knowledge, is at least as important, as literature, and that the scientific student must no longer be handicapped by a linguistic (I will not call it literary) burden, the equivalent of which is not imposed upon his classical compeer.

Let me repeat that I say this, not as a depreciator of literature, but in the interests of literature. The reason why our young people are so often scandalously and lamentably deficient in literary knowledge, and still more in the feeling and the desire for literary excellence, lies in the fact that they have been withheld from a true literary training by the pretense of it which too often passes under the name of classical instruction. Nothing is of more importance to the man of science than that he should appreciate the value of style, and the literary work of the school would be of infinite value to him if it taught him this one thing. But I do not believe that this is to be done by what is

called forming one's self on classical models, or that the advice to give one's days and nights to the study of any great writer, is of much value. "*Le style est l'homme même*," as a man of science who was a master of style has profoundly said; and aping somebody else does not help one to express one's self. A good style is the vivid expression of clear thinking, and it can be attained only by those who will take infinite pains, in the first place, to purge their own minds of ignorance and half knowledge, and, in the second, to clothe their thoughts in the words which will most fitly convey them to the minds of others. I can conceive no greater help to our scientific students than that they should bring to their work the habit of mind which is implied in the power to write their own language in a good style. But this is exactly what our present so-called literary education so often fails to confer, even on those who have enjoyed its fullest advantages; while the ordinary schoolboy has rarely been even made aware that its attainment is a thing to be desired.

I venture to lay these last observations before you, because we have heard a good deal lately of schemes for the remodeling of the University of London, which has done so much, through its Faculties of Science and Medicine, to promote scientific instruction. As a member of the Senate of the University I am necessarily greatly interested in such projects, and I greatly regret that I have been unable to take part in the recent action concerning them. This is not the time or the place for the discussion of any of these proposals, but many of my hearers must be as warmly interested in them as I am myself, and it may not be out of place to submit two questions for their serious consideration.

In the interests of science, will any change be satisfactory which does not lighten the linguistic burden at present imposed on students of science and of medicine by the matriculation examination?

And again, in the interests of science, will any change be satisfactory which does not convert the examining university into a teaching university? And, by that last term, I do not mean a mere co-operative society of teacher-examiners, but a corporation which shall embrace a professoriate charged with the exposition and the advancement of the higher forms of knowledge in all its branches.

The future both of pure science and of medicine in this country is, I think, greatly interested in the answer which Fellows of this Society, after due meditation, may be disposed to give to these questions.

I have to announce an unusually large number of changes in the staff of the Society.

Last December we regretted to receive the resignation of Mr. Walter White, so long our Assistant Secretary, whose faithful and efficient services, continued for more than forty years, are well known to all the Fellows of the Society. The minutes of the council record our appreciation of Mr. White's services, and our endeavor to give as substantial a form as possible to our hearty recognition of his deserts. The vacancy thus caused has been filled up by the appointment of Mr. Herbert Rix, whose work since he has held the office of clerk has been such as to justify the confidence of the officers, not only that the functions hitherto discharged by the assistant secretary will be as well performed as heretofore; but that, if the interest of the Society should demand it, we may throw still more important duties upon him. I receive the most favorable reports of the efficiency of Mr. James, who has been appointed to the office of clerk in place of Mr. Rix.

Notwithstanding my release from all serious work, my health remained so very indifferent for some months after my return to England that I felt it my duty to the Society to bring the question of my resignation of the presidency, on the present anniversary, before the council which met on May 20. My colleagues were kind enough to wish that my final decision should be deferred, and I need hardly say how willing I should have been to retain my honorable office if I could have done so with due regard to the interests of the Society, and, perhaps, I may add, of self-preservation.

I am happy to say that I have good reason to believe that, with prolonged rest—by which I do not mean idleness, but release from distraction and complete freedom from those lethal agencies which are commonly known as the pleasures of society—I may yet regain so much strength as is compatible with advancing years. But, in order to do so, I must, for a long time yet, be content to lead a more or less anchoritic life. Now, it is not fitting that your president should be a hermit, and it becomes me, who have received so much kindness and consideration from the Society, to be particularly careful that no sense of personal gratification should delude me into holding the office of its representative one moment after reason and conscience have pointed out my incapacity to discharge the serious duties which devolve upon the president, with some approach to efficiency.

I beg leave, therefore, with much gratitude for the crowning honor of my life which you have conferred upon me, to be permitted to vacate the chair of the Society as soon as the business of this meeting is at an end.

As I am of opinion that it is very undesirable that the president should even seem to wish to exert any influence, direct or indirect, on the action of the Fellows assembled in general meeting, I am silent respecting the proposals embodied in the new list of the officers of the Society which my colleagues and I have unanimously agreed to submit for your consideration.

The president then proceeded to the presentation of the medals:

The Copley medal is awarded to Prof. August Kekule, of Bonn, whose researches in organic chemistry, extended over the last five and thirty years, have been fruitful of results of high importance in chemical science. The great work of Prof. Kekule's life, that which has raised him to the highest rank among the investigators of the day, is his general theory of the constitution of carbon compounds, in which the now universally accepted conception of the constitution of those compounds was first clearly and definitely stated.

A development of the fundamental theory led Kekule to the discovery of the constitution of an exceedingly numerous and very complex class of compounds, which he has named the aromatic compounds, and his theory of the constitution of the aromatic compounds has suggested and guided innumerable investigations. The marvelous success obtained by many of his followers and pupils in building up artificially complex substances which had defied the efforts of all previous investigators affords tangible evidence that Kekule's labors have given us a deeper insight into the order of nature.

One of the royal medals is awarded to Prof. Hughes, F.R.S., for a series of experimental investigations in electricity and magnetism, which are remarkable alike for ingenuity of contrivance, for the simplicity of the apparatus employed, for the delicacy of the indications afforded, and for the wide applicability of the instruments invented to researches other than those for which they were originally designed.

The microphone, the induction balance, and the sonometer are instruments by which inconceivably minute electrical and magnetic disturbances not only make themselves loudly audible, but may be definitely measured; and their application has opened new lines of inquiry.

The other royal medal is awarded to Prof. E. Ray Lankester, F.R.S., for his labors, now extending over more than twenty years, in the field of animal morphology (especially invertebrate anatomy and embryology) and of palæontology.

Prof. Lankester has been active in many directions, and has everywhere left his mark, not only as an energetic teacher and accurate worker and a philosophical thinker, but as one who, in times when the example is more than ever valuable, has always been careful to remember that speculation should be the servant and not the master of the biologist.

The Davy medal is awarded to Prof. Stas, of Brussels.

Prof. Stas' great research, for which it is proposed that the Davy medal be awarded to him, is that on atomic weights. There are probably no researches in chemistry, the results of which appeal so little to the imagination, and which are so little applauded, as those on atomic weights, yet for difficulty and importance they are hardly surpassed by any. The determination of these fundamental constants of chemistry has engaged the attention of many of the leading chemists, and before the time of M. Stas' experiments, an immense amount of careful labor had been bestowed on finding methods for the more accurate and complete purification of the compounds employed for the purpose.

The indefatigable and conscientious care which M. Stas has devoted to the redetermination of a certain number of the most important atomic weights, and the marvelous skill with which he has overcome the various difficulties which successively presented themselves, render his memoir on the subject one of the most remarkable and valuable of chemical monographs.

I regret to say that the state of M. Stas' health has not permitted him to be with us to-day, but the representative of his sovereign, the King of the Belgians, in this country has kindly consented to receive the medal for him.

M. le Baron Solvyns, I request your Excellency to be so good as to receive the medal awarded to M. Stas; and to assure him of the pleasure which it gives the Royal Society to show their sense of his high merits, by asking his acceptance of this memorial of his illustrious predecessor, Humphry Davy.

EVOLUTION.—LATEST ADVANCES OF THE DOCTRINE OF DARWIN.

By Prof. EDWARD D. COPE and WM. HOSEA BALLOU.

W. H. B.—What do you consider to be the

PRESENT STATUS OF THE THEORY

of evolution as advanced by Spencer and Darwin? Have the doctrines of these men maintained their position in the scientific world, or are they losing adherents?

E. D. C.—The belief that vegetable and animal species have been produced by changes introduced in the process of ordinary descent is general among naturalists. Scarcely a man who is an investigator and contributor to scientific literature can be found who does not hold this belief as thoroughly as he believes in the laws of chemical affinity or of planetary motion.

W. H. B.—Why is it, then, that these gentlemen fail to impress their belief on the general public?

E. D. C.—A real knowledge of the principles of natural history is less common among the average intelligent Americans than Englishmen and Germans. This results partly from the fact that we have not as good text-books and teachers for schools, and partly because we have not yet developed as large a number of popular writers on natural history subjects as exist in Germany and England. Our naturalists have such a field of novelty before them that they have not time to write popular books. The time will come, however, when this will be changed, and then our people will take more interest in the natural sciences.

W. H. B.—Is there opposition to such studies from the side of theologians on account of the prevalent opinions of naturalists?

E. D. C.—In some places one sometimes hears such views expressed, and sees appointments made to positions which can only be accounted for on the supposition that such feelings exist. However, this is much less the case in England, and will disappear in America. In fact, the scientific profession is greatly indebted to the gentlemen of the ministry for many of its best representatives, and we probably gain more recruits from their congregations than from any other source.

W. H. B.—It is sometimes said that

THE VIEWS OF MR. DARWIN

do not represent those of the present day. What are your opinions on this point?

E. D. C.—It is true that Mr. Darwin did not, in the opinion of many naturalists, go to the bottom of the question of the origin of species, although he did much to demonstrate the general fact of evolution by descent. He explained very fully the reasons why animals which make advantageous changes of structure should be preserved and other animals be lost; but he did nothing to show how such changes should be introduced in the first place.

W. H. B.—We must remember that Darwin produced volumes of creative thought, requiring long years of experiments. He did not live to complete his work. Further, the theory of evolution itself was evolved and had its origin seven centuries before the Christian era. Darwin was the greatest link in this chain of thinkers, which included several Grecian philosophers, Kant, Goethe, Lessing, Herder, St. Hilaire, Lamarck, and others. Has any plausible theory been advanced to account for the beginning of new structures in animals and plants?

E. D. C.—The theory of Lamarck, of origin by use and loss by disuse, is not only a reasonable proposition, but it has been thoroughly confirmed by late researches into the history of animals which have lived during the past ages; that is, by the study of palæontology. The theory of Lamarck has also been extended and modified, chiefly by the labors of American naturalists.

W. H. B.—Will you speak of the evolutionary school that is growing up in this country, and its distinguishing opinions?

E. D. C.—The changes introduced into the original Lamarckian hypothesis are numerous and important. As propounded by its author, this theory was very general, and was not demonstrated, but only rendered probable. A very important consideration was omitted altogether. Lamarck only went one step back of Darwin in asserting that use caused the growth of and changes in animal structures. Like Darwin, he omitted to account for the first appearance of

THE BEGINNINGS OF STRUCTURES,

for that which does not exist cannot be used. Hence the importance of *effort* has been insisted upon as supplying the deficiency. It is believed, since effort is the beginning of use, and produces its results through use, that it (effort) may produce its results without the intermediation of use, and cause nutrition to make new forms and structures.

W. H. B.—What are the results obtained from the study of fossil animals?

E. D. C.—The study of palæontology has brought to light genealogical lines of animals, or phylogenies, as they are called, showing clearly the changes which have produced the animals on the earth to-day, and many others now extinct. We trace the gradual changes in all parts of the structure (or the hard parts, which are of course the only ones preserved). We learn that these parts are plainly due to the contact and conflict which the animals have sustained with nature outside of themselves, by the exercise of the energy which they have within themselves.

W. H. B.—You mean to say that the changes in animals have resulted from their actions in various ways?

E. D. C.—Yes. I mean to say that the attempts to run and to dig and to climb and to fly have undoubtedly caused gradual changes after a lapse of time in the lengths and shapes of the bones, which have ultimately improved and developed them into more perfect levers, pulleys, etc., for the various purposes for which they are employed. This is a partial expression of the doctrine of kinetogenesis, or that of

THE ORIGIN OF STRUCTURES

by motion.

W. H. B.—It is true that most animals can move; but are not many species attached to other objects, especially many sea animals? How about these, and about plants, which are always fixed?

E. D. C.—All fixed animals, in their early stages, are free moving, generally free swimming. When they get attached, they soon become fully grown. It is supposed that in early geological ages such animals were free for a length of time sufficient to enable them to develop many of their organs. Most animals which become fixed get very degenerate after this time. As to plants, they had the same history. In their earliest stages the lowest aquatic plants and some others are free swimmers. It is probable that such were the ancestors of all plants.

W. H. B.—But how do you account for the origin of thousands of different species of land plants?

E. D. C.—The differences of plants are much more geometrical than those of animals. They consist largely of lengthening and shortening of different parts of the axis, or stem, or its branches. These changes have been occasioned by excess or deficiency of nourishment at those points. The characteristics of flowers are thought to have been largely occasioned by insects.

W. H. B.—You evidently attach more importance to life than some naturalists and philosophers. It is very common to hear the origin of species treated as if it were merely the result of unintelligent force grinding out a result by means which one might say are quite regardless of life.

E. D. C.—Such an opinion is not easily maintained in view of the intelligence to be seen in the

ADAPTATION OF MEANS TO ENDS

in animal machinery and in the habits and ways of the animals themselves. I have always been of the opinion that there is some connection between these two facts, and I have striven to ascertain what that connection is. I believe I have discovered it in the doctrine of kinetogenesis and the kindred one of archæsthetism.

W. H. B.—What is this doctrine of archæsthetism?

E. D. C.—It states the existence of consciousness (or sensation) prior to organization in the world of life; and that the organization of the structure and machinery of living things has always been due primarily to sensation or consciousness in the matter which presents the structure and the change. Primitive consciousness must not be regarded as anything but the simplest capacity to feel. If structure is the result of motion, and motion was originally directed by consciousness, it is evident that the beginning of living structures has been in consciousness.

W. H. B.—But how can this doctrine be reconciled with received ideas of unconscious life, which is supposed to be so general? For instance, you do not believe in the consciousness of plants?

E. D. C.—The two doctrines are perfectly consistent, and are in fact necessary to each other. Nothing is better known than that when an action has become a habit it is no longer necessary for its performance that the performer be conscious, whether he be a man or lower animal. We all know this in our own experience. The fact is continually impressed upon us in cases of mental diseases. I suspect that all of the functions of our bodies, such as digestion, etc., are simply habits which have become unconscious and automatic from a conscious and determinate beginning in the first of animals.

W. H. B.—Do you account in this way for the pro-

cesses of plants and animals which are imitated in the laboratory in later times, and are supposed to be purely chemical in their nature?

E. D. C.—Not at all. What the connection is between these chemical processes and life is yet very obscure. It is evident, however, since different animals and plants produce different substances in similar localities, that the life principle has something to do with the affair, somewhat as the chemist arranges his laboratory when he imitates the process. It is evident also that life has had to build the plant and animal laboratory which does such wonderful things, and this leads me a step farther. It leads me to suspect that even chemical force may be under the control of life force to some degree. Without the quality of life—a form of energy as I believe it to be—the material of animals and plants cannot hold together. It would not surprise me if it should some day be discovered that all forms of energy are simply automatic and dead products of primitive life energy. The process of automatization, as it might be called, has only gone farther in these forces than in the case of the automatic life forces. This is what I call creation by catagenesis, or the hypothesis of that name.

W. H. B.—Are you, then, a believer in the so-called "vital force"?

E. D. C.—I am not. The doctrine of a "vital force" is as meaningless as would be a doctrine of a *dead force*. The forces of living animals are mainly forms of energy working under the direction of past or present consciousness. One of these forces has become so specialized in plants and animals as to make it necessary to distinguish it. I refer to the force that builds tissue in the embryo, in or nearly in the image of the parent; this is growth force, or bathmism.

W. H. B.—Do you think that these opinions will meet with general acceptance?

E. D. C.—Of course they will in time, if they are true. Whether they are true or not remains to be seen. They will have to take their chances, and will be well ventilated sooner or later.

W. H. B.—Do you not think that such questions enter into the field of metaphysics, and are not easily taken up by the naturalist?

E. D. C.—Whatever they are, they belong to the most obvious and

EVERYDAY PHENOMENA,

and as such are just as much the objects of our observation and criticism as any of those with which the student of anatomy or botany concerns himself. Inductive reasoning from the phenomena of this kind is not only possible but necessary for the philosopher who would understand the great truth of creation by evolution.

W. H. B.—How do you suppose the theologians will look on such doctrines?

E. D. C.—It is difficult to say. Probably some will condemn them as Godless or as tending to pantheism. For my own part, I may say that such opinions give me a better ground for belief in the possibility of the existence of Deity, and a continuation of existence after death, than any I have been able to derive from any other source. I am convinced that while much has been said of the end or extinction of life, too little has been thought and said of the beginnings and spread of life. Life evidently has as many beginnings as endings.

W. H. B.—Are there any further statements on these views of evolution accessible to the general public?

E. D. C.—Important contributions to the Neo-Lamarckian views have been made in this country by John A. Ryder, Alpheus Hyatt, and others. Appleton & Co. have in press a volume of essays on the subject which I have published in the *American Naturalist*, the *Popular Science Monthly*, etc.

[SCIENCE.]

HATCHING THE EGGS OF THE COD.

FOR four seasons experiments have been carried on for the purpose of discovering a practical method of hatching out the eggs of the cod, one of the most fertile and valuable of the food-fishes found off our coast. During the period mentioned no less than forty forms of apparatus have been devised and operated, with varying success, by different persons connected with the work of the United States fish commission. Up to the present time no device has fulfilled the required conditions, even approximately, with such success as the apparatus just devised by H. C. Chester, superintendent of the Wood's Holl station of the commission.

This apparatus is essentially automatic, and needs so little attention that one man will by its aid readily care for a hundred million eggs. It consists of a trough seven feet six inches in length, two feet in width, and two feet four inches in depth. At about one foot from either end, vertical wooden partitions, extending to within four inches of the bottom of the trough, are secured. This leaves a space about five feet six inches in length between the partitions. In this space six or eight large glass jars are supported upon a frame, with their tops downward. Those used for the purpose at Wood's Holl are ordinary cylindrical, four-gallon specimen jars, with a half-inch hole drilled in the center of the bottom. The stoppers of the jars are removed, and a single thickness of coarse cheese-cloth is secured over the mouth with strong twine. The jar is then inverted and lowered into the trough, so that its bottom is about even with the top of the trough. Strips nailed across the top of the trough serve to keep the jars upright.

The accompanying figure, showing the device in longitudinal vertical section, modified and designed on a somewhat smaller scale than the device now in use, and accommodating only four jars (two in a row), will enable the reader to get a clear conception of the way in which the apparatus is used. The trough, A, is filled with unfiltered sea-water through the faucet, *i*, the water rising to the level of the line, *a*, before the capacious outlet siphon, *s*, begins to operate. This siphon, through which the water runs out of the trough faster than it comes in at *i*, soon brings the water down to the level of the line, *b*, when the siphon takes in air and ceases to operate, after which the trough again slowly fills up with water to the level of the line, *a*. This process is repeated automatically, and as long as the water is permitted to flow through the device. It requires ten minutes for the water to rise or fall from the one level to the other, and since the jars have only a cloth tied over the mouth below, the water rises and falls to the same extent in them. This very slow and gentle rise and fall of the water in the jars and trough have been found sufficient to aerate the eggs, and give them all the movement they need.

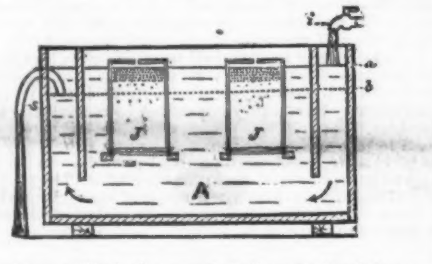
The majority of the eggs in this contrivance float at the surface. Some, of course, remain suspended below the surface; but an exceedingly small percentage of the eggs ever sink and die, as in almost all of the other forms of apparatus hitherto used. The result is that the mortality is probably under five per cent., a percentage of loss not greater than that experienced in the most successful treatment of shad ova.

The freshly fertilized ova, treated with an abundance of good milt, are introduced into the hatching-device through the hole in the center of the bottom of each jar by means of a glass funnel. Beyond an occasional siphoning off of the sediment on the bottom of the trough and the cloth covers of the jars, the eggs require no attention until hatched.

Heretofore, great mortality has been caused by the use of metal in the construction of the hatching-vessels and strainers. Since the adoption of glass, wood, and cloth as the only materials used in the construction of the hatching-apparatus here described, combined with the very gentle movement to which the eggs are subjected, complete success has been attained. The eggs oscillate up and down through a space of only five inches from the level of *a* to that of *b*, and, withal, so gently that they suffer no hurtful shocks of any kind whatever. Captain Chester's device will doubtless be used with great advantage in the propagation of the Spanish mackerel. In twenty-four hours the latter would be ready to be set free from the apparatus, whereas it requires eleven or twelve days to hatch the eggs of the cod, with the temperature of the water ranging from 45° to 48° F.

Each of the jars, J, is seventeen inches high by nine inches in diameter, and will hold from one-half to one million of cod-eggs; so that an apparatus of the style shown below, and occupying not much over a square yard of space, would accommodate from two to four millions of ova, in four jars.

These experiments show that violent movement of the eggs of the cod is of no advantage; that such movement is, on the contrary, injurious, if not mortal, when continuously maintained. The requisite conditions for successful hatching of this important food-fish



having been settled, the great station of the fish commission at Wood's Holl affords unlimited opportunities for conducting the work for at least three months of the year, during which time from five hundred to one thousand millions of eggs might readily be hatched out by the aid of the Chester apparatus, and set free in the adjacent waters.

Since my arrival here, I have observed that, some days after hatching, the larval integument over the head of the embryo cod is raised more and more from the top and sides of the brain. A spacious serous cavity is thus formed over the brain, so that when the embryo is viewed from the front, it seems as if it bore a sac on the head almost as large as the yelk-bag formerly had been, attached to the top and sides of the head. On account of the fact that the young larvæ of the cod seem to delight to remain near the surface, it has occurred to me that this vesicular sinus above the brain is of use in buoying the young embryos up after they have escaped from the egg. That this is actually true, I have every reason to believe from the circumstance that embryos a few days old never rest in the water in a horizontal position, but with the head uppermost, and the tail slanting backward and downward from it at an angle of 45°. When swimming, they move horizontally; but at once, upon coming to rest, the young fish assumes a slanting attitude, the tail dropping down into the inclined position, while the head is thrown up. The large sinus here described was first observed by me, in a less developed condition, on the head of the embryo Spanish mackerel, in 1880. The space in this sac in that species I called the supracephalic sinus.

Since the foregoing was written, we have discovered that the specific gravity of the sea-water has a great deal to do with the healthy development of the eggs of the cod. By accident a broken valve admitted some fresh water to our salt water tank, causing the specific gravity to fall from 1·0256 to 1·021 or 1·022. In this density the eggs immediately sank, causing us to lose over two millions. After this unfortunate experience, and also judging from the fact that ever since the break in the valve has been mended no eggs have gone down, we have concluded that it is natural for cod eggs to float, and that under no other conditions will normal development be accomplished.

JOHN A. RYDER.

Wood's Holl, Dec. 21.

SPREAD OF CHOLERA.

LOCAL physicians and sanitary officers agree in saying that the disease spreads most rapidly along the water courses. By the rivers it seems to have been carried from one village or city to another, and the movement of the disease is from the source and toward the mouth of the stream, and not in the other direction. For example, the cholera having been carried in some way from Valencia to the village of Archena, on the Segura River, it quickly made its way down the stream to Murcia, and is now epidemic throughout the entire course of that stream from Archena to the sea. But no cases have occurred above Archena. In the province of Valencia the towns that have suffered most severely lie along the course of the river Jucar and below the town first attacked. These facts indicate that the germs were carried down by the water, and probably swallowed by persons who used the river water for drinking.

That the water of the rivers and irrigating ditches was an active agent in spreading the disease is shown again in other ways. The most malignant cases are always found near the rivers and near these ditches, into which the river water flows. But those who use water from artesian wells generally escape infection. In a group of 600 persons who used artesian water there were only two cases and one death, although the pestilence raged around them in families that drank river water. Of three villages lying in a small circle in Valencia, two used river water, and suffered severely, while the other used artesian water, and has not yet had a case of cholera. These facts are of considerable value, although they only confirm the soundness of principles established long ago. They serve to emphasize the advice of physicans and sanitarians that, when an epidemic of infectious disease prevails, the people should boil water before using it for any household purpose.

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